AD NUMBER

ADB028935

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; JUN 1978. Other requests shall be referred to Army Armament Research and Development Command, Large Caliber Weapons Systems Lab., Dover, NJ 07801.

AUTHORITY

USARDC ltr, 10 Apr 1984

AD B028935

AUTHORITY: USARDC Ltr, 10 APR 84

(2) 3, 5

AD

AD-E400 175

LEVEL II

(9) TECHNICAL REPORT ARLCD-TR-77062 (12)

(14)

(6) DYNAMICS OF THE PIN PALLET RUNAWAY ESCAPEMENT.

(10) G. G. LOWEN
CITY COLLEGE OF NEW YORK

F. R. TEPPER
ARRADCOM

(12) 110 p.

(11) JUNE 1978

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

(15) DAAG29-76-G-0058

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report ARLCD-TR-77062	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DYNAMICS OF THE PIN PALLET RUNAWAY ESCAPEMENT		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. G. Lowen, City College of New York F. R. Tepper, ARRADCOM		8. CONTRACT OR GRANT NUMBER(s) DAAG-29-76-G-0058
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARRADCOM Fuze Division, LCWSL ATTN: DRDAR-LCF Dover, NJ 07801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS ARRADCOM ATTN: DRDAR-TSS Dover, NJ 07801		12. REPORT DATE JUNE 1978 13. NUMBER OF PAGES 109
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) ARRADCOM Fuze Division, LCWSL ATTN: DRDAR-LCF Dover, NJ 07801		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to US Government agencies only because of test and evaluation, June 1978. Other requests for this document must be referred to the Commander ARRADCOM, ATTN: DRDAR-TSS, Dover, New Jersey 07801.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Runaway escapement
Pin pallet
Escape-wheel
M525 fuze
Safing and arming

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This investigation developed a workable computer simulation of the pin pallet runaway escapement which can provide the basis for the analysis and synthesis of various safing and arming devices. The dynamics of the various regimes of escapement motion are modelled. Coupled motion, impact, and free motion are considered. Sensing equations for the determination of the instantaneous positions of the pallet pin and the escape-wheel form the basis of the controls in the computer program.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. The simulation is applied to the timing of the mechanism of the M525 fuze with an assumption of constant input torque to the escape-wheel. The influence of changes on such parameters as escape-wheel torque, pallet moment of inertia, center distance, pallet radius, etc., are explored in detail by appropriate computer runs. Agreement has been found with existing experimental data. Finally, recommendations for continued work are given.

ACKNOWLEDGMENT

The first author gratefully acknowledges the support of the research done, under Grant No. DAAG-29-76-G-0058, by the Army Research Office. The assistance rendered by Picatinny Arsenal and the City College computation centers is also greatly appreciated. Last, but not least, the first author wishes to thank his students, Mr. R. Van Nostrand and Mr. R. Chin, for their invaluable help.

TABLE OF CONTENTS

Appendixes

Tables

Figures

INTRODUCTION

It was the aim of the present investigation to develop a realistic and workable computer simulation of the dynamic behavior of the pin pallet runaway escapement which can be used in the analysis and synthesis of various safing and arming devices. This goal has been achieved.

This report describes and formulates the dynamics of the various regimes of motion which form the basis for the simulation. The computer program and its controls are presented in detail. The simulation is applied to the time delay mechanism of the M525 fuze and the influence of various parameter changes is explored. Previous experimentation and practical experience with this mechanism confirmed the results of the computations. Finally, recommendations for continued work are given. The previous work done in this field is listed in references 1-15.

SIMULATION OF PIN PALLET RUNAWAY ESCAPEMENT

The present effort on the pin pallet escapement represents an extension of the work of M. E. Anderson and S. L. Redmond (ref. 7). New methods of contact kinematics for coupled motion, of contact sensing, and of computational controls are developed.

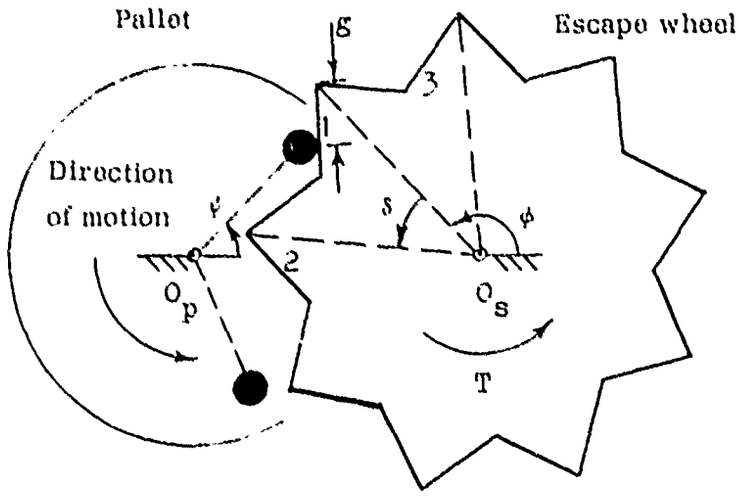


Figure 1. Coupled motion

The following outlines the overall assumptions and derivations for the various regimes of motion. A detailed description of the actual computer program and its controls is then given.

Coupled Motion

Figure 1 shows the upper pallet pin[1] being driven in coupled motion by tooth no. 1 of the escape wheel (top contact). The escape-wheel angle φ is defined by the line from the escape-wheel pivot O_s to the tip (without radius) of the contacting tooth (or the one about to make contact) and the line connecting O_s to the pallet pivot O_p. Similarly, the angle ψ, which is defined by the line from O_p to the active pallet pin center (top or bottom) and the center line, describes the motion of the pallet. The escape wheel is driven by the constant moment T in the positive direction of rotation. While it is assumed that friction acts on the pallet pin/escape wheel tooth interface, it is neglected at both pivots since investigation showed that its effects are negligible when the pivots are of the usual small diameter.

The quantity g, which represents the distance from the contact point to the tip of the escape-wheel tooth, is used to determine the end of coupled motion. Appendix A contains derivations for this expression, as well as all other kinematic quantities associated with coupled motion. Appendix B, with the help of appendix C, gives the derivation of the differential equation of coupled motion in terms of the escape-wheel angle φ (eq. B-10).

Free Motion

When coupled motion is finished (i.e., $g = 0$) or when separation of contact occurs after impact, the escape wheel and pallet move independently of each other in free motion. Figure 2 shows this free motion for the bottom phase of the action, i.e. the bottom pallet pin is about to make contact with tooth no. 2 of the escape-wheel. The constant torque T continues to act on the escape-wheel, while the motion of the pallet depends only on its initial conditions. Again, any frictional retarding moments at the pivots are neglected. Position sensing during free motion is based on g', the distance of the pallet pin center from the tip of the escape-wheel

[1] This report uses the word upper when referring to entrance motion and lower when referring to exit motion.

tooth (parallel to the face of the tooth) and f, the distance between the pallet pin and tooth surfaces normal to the tooth). Expressions for these quantities are derived in appendix D. The differential equations for the free motion of the pallet and the escape-wheel are derived in appendix E.

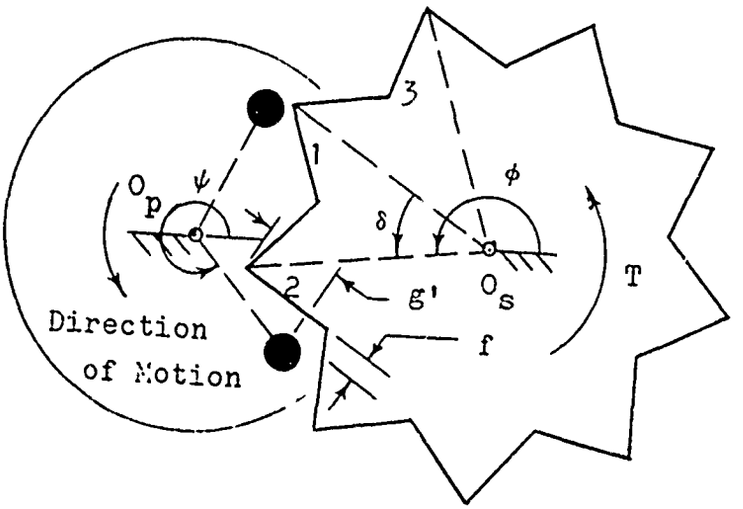


Figure 2. Free motion

Impact

Impact follows free motion whenever f equals zero, g' is smaller than zero, and the relative velocity between the contacting surfaces warrants it. Such an impact usually reverses the motion of the pallet (fig. 3) and under certain circumstances also reverses the motion of the escape-wheel temporarily. While the impact equations, derived in appendix F, allow for both normal and tangential impulses to produce changes in the angular momenta of the pallet and escape-wheel, the computer program presented here neglects the tangential impulse for the sake of simplicity. The classical coefficient of restitution formulation is used to account for the energy loss during impact.

Figure 4 shows free motion for the subsequent top phase of the motion, i.e. the top pallet pin is about to make contact with tooth no. 3 of the escape-wheel.

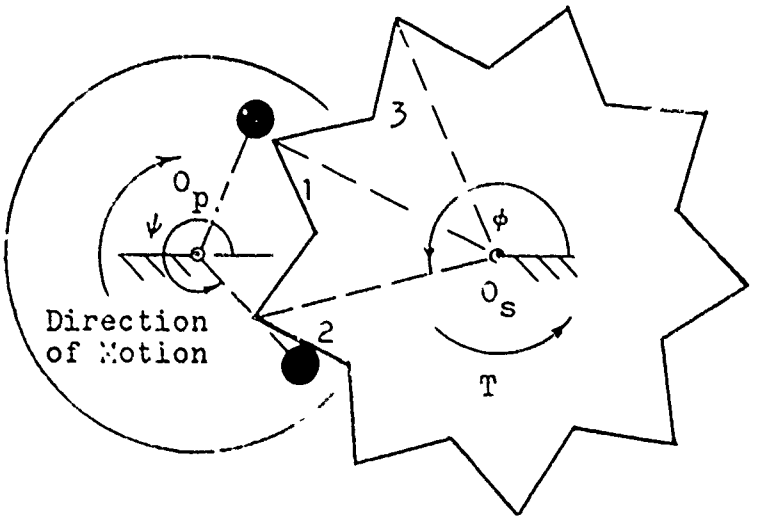


Figure 3. Impact

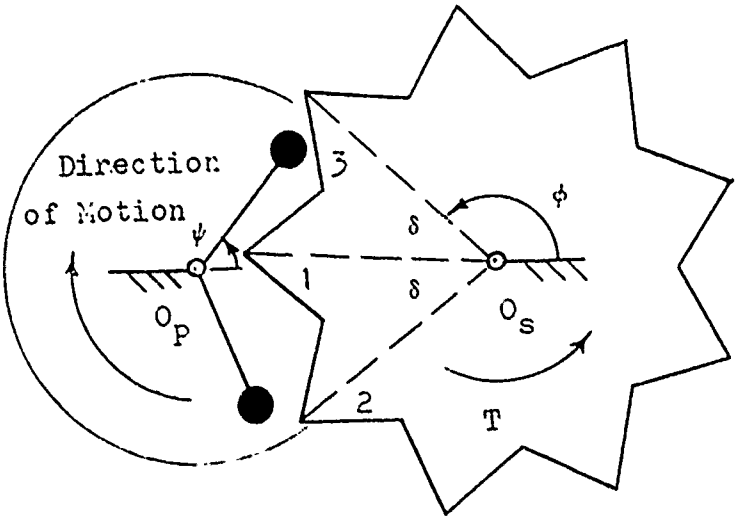


Figure 4. Impending top contact

All kinematic and dynamic expressions are derived in such a manner that they are valid for top and bottom action. The simulation recognizes only contact on the front faces of the escape-wheel teeth. Pathological conditions, such as impact on the tips or the back faces of the escape-wheel teeth are not considered. (The control quantities g and g' make it clear that when such a condition exists the computation can be discontinued.)

Escapement Nomenclature

Figure 5 shows a schematic representation of the pin pallet escapement and indicates its basic geometric nomenclature.

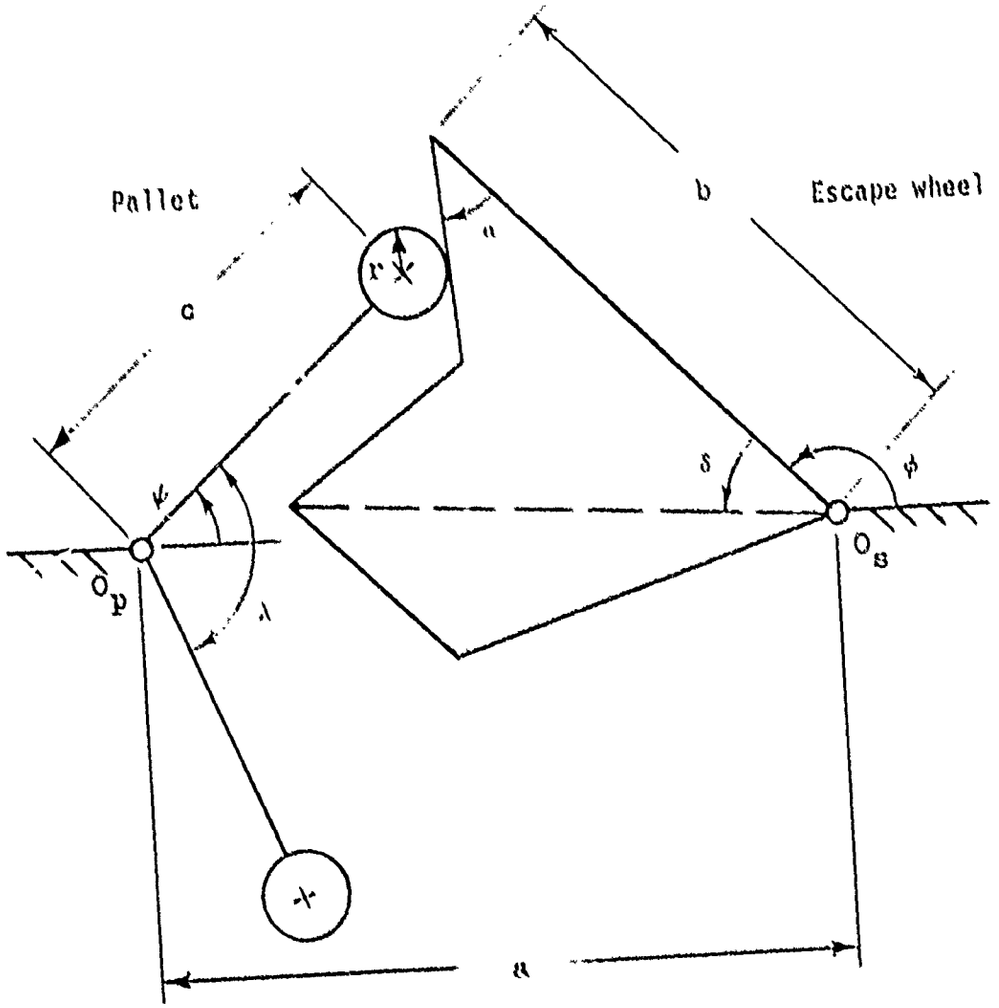


Figure 5. Escapement nomenclature

a = Distance between pivot points O_p and O_s

b = Escape wheel radius

c = Pallet radius (equal on top and on bottom for simplicity)

r = Pallet pin radius (equal for top and bottom)

α = Escape-wheel tooth half angle

δ = Angle between escape-wheel teeth

φ = Angular position of escape-wheel

ψ = Angular position of pallet

DESCRIPTION OF COMPUTER PROGRAM

The following gives the essential steps of the computer program as listed in appendix G[2]. The flow chart of the program is shown in figure 6. The choice of variable designations was made in such a way that they differ as little as possible from the nomenclature used in the various derivations in appendixes A to F and H.

The main program starts the simulation with top contact coupled motion at a starting angle $\varphi = 135°$ (called PHID in the computer program) and a cumulative-escape-wheel angle PHITOT of 0°. The choice of this starting angle is connected with the geometry of the example mechanism used ($\varphi_M = 132.487°$ for the example mechanism).

Coupled Motion (location 100)

To solve the differential equation of coupled motion (see equation (B-10) of appendix B) the main program calls on an available fourth-order Runge-Kutta routine.[3] The subroutine FCT computes all needed values and presents the second-order differential equation in terms of two first-order ones to RKGS. PHI (1) and PHI (2) represent the angle φ and the angular velocity $\dot{\varphi}$, respectively. The associated subroutine OUTP is responsible for printing out the results of the integration together with the current values of time, g, $\dot{g}$, ψ, $\dot{\psi}$, and PHITOT. In addition, it has the task of deciding whether coupled motion is to be continued. Coupled motion is continued

a. as long as $g < 0$. (See equation (A.12) and note, that because of the nature of the coordinate system, g is always negative while the pallet pin makes contact with the escape-wheel tooth.) And,

[2] The program shown is written in FORTRAN for the CDC System at ARRADCOM, Dover, NJ. It is also available in a slightly modified form for the IBM System/360 at the City College of New York.

[3] RKGS Routine, IBM System/360 Scientific Subroutine Package, (360A-CM-OX3) Version III.

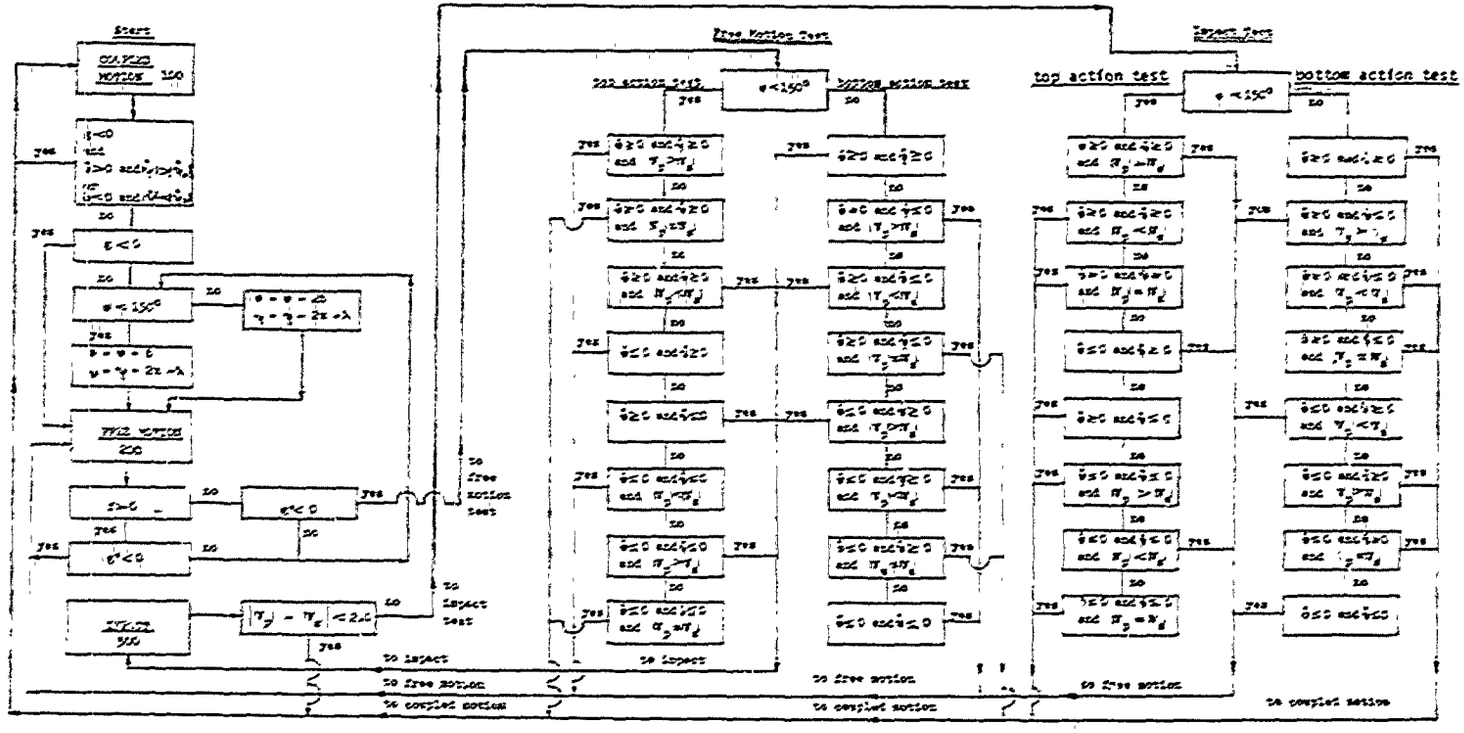


Figure 6. Flow chart for simulation of runaway escapement

b. for a positive (counterclockwise) rotation of the escape-wheel, if the succeeding absolute value of ψ (DPSI) is larger than the one obtained from the preceding computation (called DPSIP). These values of $\dot{\psi}$ are computed with the help of equation (A.18), which assumes closure. This condition is necessary, since in coupled motion when $\dot{\varphi}$ is positive the escape-wheel can only drive the pallet, not slow it down. If such a slowdown is indicated, it means that pallet and escape-wheel have separated and free motion will take place. Or,

c. for a negative rotation of the escape-wheel (which may occur after impact), a succeeding absolute value of $\dot{\psi}$ must be smaller than the preceding one. If for some reason the escape-wheel should speed up and cause the computation to show a larger succeeding value of $\dot{\psi}$, it would also serve as an indication that closure has terminated and free motion has started.

To make this process less sensitive, the last two conditions will only be violated when the absolute magnitude $|\dot{\psi}| \geq 1$ rad/sec.

Thus, when control is returned to the main program, it is either because the pallet pin has left the end of the tooth and there is no further possibility of coupled motion or the pin has disengaged from the inside of the tooth. In either case, free motion results and control is eventually shifted to the subroutine FREE (location 200). This is done directly if $g < 0$. In the case that $g < 0$, the main program must decide whether the preceding computations have been made for top or for bottom action and whether the next contact will occur on top or on bottom. In the sample mechanism, $g = 0$ when φ is approximately 146° for top action and approximately 207° for bottom action. (The values of φ_0 for top and bottom action are located in the section on the example mechanism). If $\varphi \leq 150°$, all possibility for top contact is ended and φ must be incremented by the tooth angle δ (see figures 2 and 5), while ψ must be incremented by the angle $(2\pi - \lambda)$. For $\varphi > 150°$, top contact is expected at the end of bottom action and φ must be decremented by the angle 2δ (see figure 4, where the new top tooth no. 3 comes into action). At the same time, the pallet angle ψ must be decremented by $(-2\pi + \lambda)$. These indexing operations have no effect on the continuous computation of the cumulative escape-wheel angle PHITOT.

Free Motion (Location 200)

After transferring the initial values for time, angles, and angular velocities from the main program, the subroutine FREE computes the subsequent positions and angular velocities of pallet and escape-wheel in free motion according to equations (E.2), (E.3), and (E.7) and (E.8), respectively, for time increments of 10^{-5} seconds. In addition to the above variables, PHITOT is also continually computed and caused to be printed out. The decision, whether or not to remain in this subroutine, is made with the help of the sensing variables, f (according to equation (D-7)) and g' (according to equation (D-11) and now called GP).

If $f > 0$ and $g' \leq 0$, free motion is continued without indexing. If $f > 0$ and $g' > 0$, free motion is also continued, but since contact is no longer possible for the component pair for which the previous computations were made, indexing takes place. This is accomplished in the same manner as described before.

If $f < 0$, control is returned unconditionally to the main program. If it finds that $g' > 0$, indexing takes place and control is given back to the subroutine, FREE. When $f \leq 0$, contact is about to take place or has just occurred. The program must decide whether this contact just represents a close approach, which will be followed by further free motion, whether it represents an impending impact, or whether it is the beginning of coupled motion. To this end, the quantities V_p and V_s (see equations (F.22) and (F.23)) are computed for the top and bottom free motion tests.[4] The first three cases of the top free motion test of the main program are illustrated in figure 7. With both angular velocities ($\dot{\varphi}$ is PHI (2) and $\dot{\psi}$ is DPSI) positive, the following three possibilities exist:

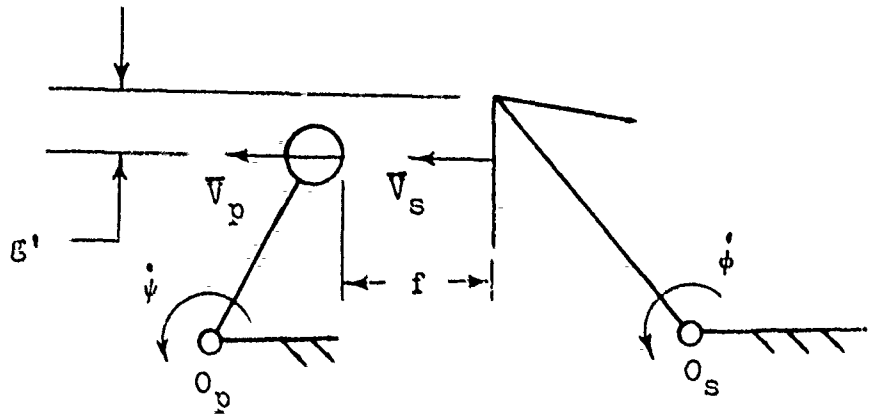
1. If $|V_p| > |V_s|$, the contacting surfaces will separate again, free motion will result, and control must be transferred to subroutine FREE (location 200).

2. If $|V_p| = |V_s|$, the escape-wheel will start driving the pallet in coupled motion, and control must be transferred to subroutine RKGS (location 99 initiates RKGS).

[4] Under the present circumstances, if $\varphi < 150°$, only top contact can follow; if $\varphi > 150°$, bottom contact will occur.

3. If $|V_p| < |V_s|$, impact will occur, and control must be given to subroutine IMPACT (location 300).

The remainder of the top free motion tests and the bottom free motion tests are constructed along similar lines for different combinations of angular velocity directions.



($\dot{\varphi}$ and $\dot{\psi}$ are positive. Distance f is enlarged.)

Figure 7. Top free motion test

Impact (Location 300)

The subroutine IMPACT uses the current values of the angular velocities $\dot{\varphi}_i$ and $\dot{\psi}_i$ and computes the post impact angular velocities $\dot{\varphi}_f$ and $\dot{\psi}_f$, applying equations (F.20) and (F.21). (Note that the tangential impact has been neglected and, therefore, $E_2 = D_1$ and $F_2 = A_1$).

After control is returned to the main program, it is decided whether free or coupled motion follows the impact. This is accomplished by considering the post-impact contact point velocities, V_p and V_s, in the impact tests, which are similar to the free motion tests.

If the contact velocities are vectorially equal to each other or if the absolute value of the difference of their absolute magnitudes is less than 2.0 in/sec (5.08 cm/sec), control is transferred to coupled motion. If these velocities are such that they indicate a subsequent separation, which is more usual, computation is transferred to free motion.

The computation is terminated when either t = .1 seconds or when PHITOT $\geq$ 315°. These conditions are related to the sample mechanism which runs less than .1 seconds for 310° of escape-wheel rotation.

EXAMPLE MECHANISM

The pin pallet escapement of the M525 fuze is used as the example mechanism. The following, first, gives the dimensions of the basic escapement (standard configuration) and then discusses certain other data and computed values which are of importance in the computer simulation.

Dimensions of the Mechanism

The standard geometric configuration has the following dimensions:

a = .1931 inches (mean center distance) (.4905 cm)

b = .15838 inches (.40229 cm)

c = .09683 inches (.24595 cm)

r = .01365 inches (.03467 cm)

α = 40°

β = 60° (see figure H-1 in appendix H)

λ = 109.337°

δ = 40°

N = 9 (number of teeth of escape-wheel)

I_p = .91 x 10^{-7} lb-sec^2-in. (moment of inertia IPAL of pallet)
(1.03 x 10^{-8} N - sec^2-m)

I_s = .17 x 10^{-7} lb-sec^2-in. (moment of inertia ISTAR of
(1.92 x 10^{-9} N - sec^2 - m) escape-wheel)

Gear Train Driving Escapement

The escapement of the M525 fuze is driven by a clock spring through a step-up gear train with a ratio of 45.98. The timing function of the fuze, which involves a delay of between 2 to 4 seconds, is accomplished once the spring driven input gear has rotated through 310°. This corresponds to a 45.98 times greater escape-wheel rotation. Since the motion becomes stablilized after one cycle of the pallet (corresponding to approximately 40° of escape-wheel rotation), one obtains an excellent idea of the total time by computing the response time for 310° of escapement rotation and multiplying this result by the aforementioned gear ratio (see the section on results for standard configuration).

Standard Torque Used in the Simulation

Measurements on actual fuzes showed that the initial torque on the escape-wheels varied between .0177 (2.000 x 10^{-3} m-N) and .031 in-lb (3.503 x 10^{-3} m-N). Since the angle of rotation of the input gear is small, the decrease in torque during the rotation is also relatively small. Therefore, a constant torque was assumed in the simulation. Its standard value was chosen to be .0177 in-lb (2.000 x 10^{-3} m-N).

Other Dimensions Associated With Standard Configuration

For purposes of control in the computer program the following other dimensions are of interest.

The maximum absolute value attainable for the dimension g for the given escapement is computed according to equation (H-4) of appendix H:

g_{MAX} = -.05467 inches (-.1389 cm)

The associated values of the escape-wheel angle φ_M are obtained with the use of equation H-10. For top action

$$\varphi_M = 132.487°$$

Because of this value, initial coupled motion is started at 135°. (See the section on the computer program.) For bottom action, this angle becomes:

$$\varphi_M = 187.518°$$

The corresponding values for the pallet angles ψ_M are found through the use of equation (A.8) appendix A and are computed with g = -.05467 and $\alpha = 40°$. For top action,

$$\psi_M = 39.491°$$

and for bottom action,

$$\psi_M = 320.396°$$

These values serve as valuable checks on the computer output.

The escape-wheel angles φ_o corresponding to g = O, i.e. the position when the pallet pin leaves the tooth in coupled motion, are obtained according to equation (H-12). For top action,

$$\varphi_o = 146.328°$$

Because of this angle, decisions concerning indexing, the free motion and impact tests are based on whether the angle φ is smaller or larger than 150°. (See the section on the description of the computer program.) For bottom action, this angle becomes

$$\varphi_o = 206.512°$$

The corresponding pallet angles are

$\psi_o = 60.138°$ for top action, and

$\psi_o = 299.869°$ for bottom action, respectively.

Finally, it is important to know the center distance between pallet and escape-wheel for which disengagement will occur. According to equation (G.14)

$$a_{dis} = .208 \text{ inches } (.528 \text{ cm})$$

RESULTS FOR STANDARD CONFIGURATION

Appendix I shows computer output for the first, second and eighth cycles of a run for the standard configuration with a coefficient of friction, $\mu = .3$, and a coefficient of restitution, $\varepsilon = .25$ (run no. 46). Table 1 summarizes the results of the first two and one half cycles. In appendix I, a cycle is defined as the interval between first contacts on top. In tables 1 and 3 the interval is between the last contacts on top.) As discussed earlier, top motion in the coupled mode initiates the program. In the subsequent first bottom action, the first impact is followed by free motion while the second impact leads to coupled motion by virtue of the cut-off criterion. Starting with the second top contact, both top and bottom action consists of two impacts followed by free motion. The subsequent third impact produces little rebound of the pallet pin and thus is the beginning of coupled motion which lasts until the pallet pin leaves the tooth.

The various impacts cause reversals in escape-wheel motion. In the actual mechanism, this backward rotation is limited by the possibility of the pin making contact with the backface of the next escape-wheel tooth. The program does not provide for the presence of this condition and any contact of this type makes itself known only if during or after the first impact, the escape-wheel angle $\varphi < 132.487°$ for top action or $\varphi < 187.518°$ for bottom action. If such a reversal of the escape-wheel takes place during coupled motion, g will be less than -.05467 in. (-.1284 cm). (See the section on other dimensions of the standard configuration for discussion of the above values.)

Inspection of table 1 shows that this condition first occurs in cycle no. 3 for top contact, i.e. $\varphi = 132.480°$. Table 2 gives the values of the maximum reversal angles for the first eight cycles. While these reversals of the escape-wheel angle never reach critical values for bottom action, they exceed critical values a number of times for top action. (The geometry lends itself more for this condition with respect to top action.)

The fact that the absolute value of g_{MAX} will be exceeded in certain configurations will be accepted or more dissipative values for μ and ε will have to be used[5]. The discussion in the section on the influence of parameter changes in the total fuze time will show that a slight increase of the center distance a decreases the absolute value of g at maximum reversal to well below g_{MAX}. This correlates with the results for $\mu = .3$ and $\varepsilon = 0$ given below.

Table 1 shows that the stability of motion is essentially established during the first cycle. The time interval per cycle, now counted between the instants when the pallet pin leaves the top tooth, is shown to be .00774 and .00773 seconds. Subsequent intervals (not shown here) are .00773, .00775, .00785, .00784, and .00773 seconds. The total time of the fuze may be obtained with the help of the time at PHITOT ≈ 310°. Appendix I shows that t(310.362°) = .06058 seconds. Thus, the total fuze delay time becomes .06058 x 45.98 = 2.79 seconds. (See the section on the example mechanism.) This result is well within the fuze requirement of between 2 to 4 seconds.

Appendix J gives portions of the computer output when the standard configuration was run with $\varepsilon = 0$, while $\mu = .3$ was kept (run no. 70). Table 3 summarizes the events of the first 3½ cycles and table 4 lists the maximum reversal values of the escape-wheel for eight cycles.

As expected, the fully inelastic coefficient of restitution causes the initial impacts to be followed by coupled motion. Now, $g < g_{MAX}$ at all times. (Again, the reversals are smaller for bottom action.) As in the first program above, the motion stabilizes immediately with cycle intervals of .00725, .00730 and .00725 seconds. Subsequent intervals, not shown here, are .00726, .00729 and .00726 seconds. The total fuze delay time is computed with t(PHITOT = 310.600°) = .05699 seconds (see appendix J). This results in 2.62 seconds.

[5] Since no high speed motion pictures of the M525 are available, it is not known whether contact with the backside of the escape-wheel tooth is ever made.

Table 1. Summary of events in the first 2½ cycles for standard configuration with $\mu = .3$ and $\varepsilon = .25$ (Program No. 46)

	Type of action	Escape-wheel angle φ (deg)	Time (sec)	Time interval (sec)	Total escape-wheel angle (deg)
Top:	start of coupled motion	135.000	0.00000		0.000
	start of free motion (end of tooth)	146.491	0.00340[1]		11.491
Bottom:	impact followed by free motion	194.179	0.00382		19.179
	maximum return motion (free)				
	continued free motion	192.911	0.00402		17.911
	impact followed by coupled motion				
	(cut-off criterion: $\|V_p\| - \|V_s\| < 2$)	193.366	0.00415		18.366
	maximum return motion (coupled)	193.281	0.00425		18.281
	start of free motion (end of tooth)	206.844	0.00645		31.844
Top:	impact followed by free motion	135.522	0.00688		40.522
	maximum return motion (free)				
	continued free motion	133.361	0.00714		38.361
	impact followed by free motion	133.435	0.00720		38.435
	maximum return motion	133.214	0.00724		38.214
	impact followed by coupled motion				
	(cut-off criterion)	133.214	0.00724		38.214
	maximum return motion (coupled)	133.540	0.00753		37.540
	start of free motion (end of tooth)	146.514	0.01114[2]	0.00774[3]	51.514
Bottom:	impact followed by free motion	193.802	0.01154		58.802
	maximum return motion (free)				
	continued free motion	192.321	0.01176		57.321
	impact followed by free motion	192.803	0.01189		57.803
	maximum return motion (free)				
	continued free motion	192.749	0.01193		57.749
	impact followed by coupled motion				
	(cut-off criterion)	192.790	0.01197		57.790
	start of free motion (end of tooth)	206.768	0.01417		71.768
Top:	impact followed by free motion	135.519	0.01460		80.519
	maximum return motion (free)				
	continued free motion	132.297	0.01487		78.297
	impact followed by free motion	133.394	0.01493		78.394
	maximum return motion (free)	133.165	0.01497		78.165
	impact followed by coupled motion				
	(cut-off criterion)	133.165	0.01497		78.165
	maximum return motion (coupled)	132.480	0.01526		77.480
	start of free motion (end of tooth)	146.496	0.01887[4]	0.00773[5]	91.496

[1] Start of first cycle
[2] End of first cycle, start of second cycle
[3] Time interval for first cycle
[4] End of second cycle
[5] Time interval for second cycle

Table 2. Maximum reversal angles and associated values of g for standard configuration with $\mu = .3$ and $\varepsilon = .25$ (Program No. 46)

	Top action		Bottom action	
Cycle No.	Maximum reversal angle, φ ($\varphi_M = 132.487°$)	g (in.) ($g_M = -.05467$)	Maximum reversal angle, φ ($\varphi_M = 187.518°$)	g^1 (in.) ($g_M = -.05467$)
1			192.910	
2	132.540	-.0547 (-.1389 cm)	192.321	
3	132.480	-.0549 (-.1394 cm)	192.303	
4	132.312	-.0555 (-.1410 cm)	192.320	
5	132.305	-.0555 (-.1410 cm)	192.485	
6	132.094	-.0562 (-.1427 cm)	191.837	
7	131.593	-.0580 (-.1473 cm)	192.078	
8	132.634	-.0543 (-.1379 cm)	192.315	

[1]Not applicable. Occurs during free motion.

Table 3. Summary of events in the first 3½ cycles for standard configuration with $\mu = .3$ and $\varepsilon = 0$ (Program No. 70)

	Type of action	Escape-wheel angle φ (deg)	Time (sec)	Time interval (sec)	Total escape-wheel angle (deg)
Top:	start of coupled motion	135.000	0.00000		0.000
	start of free motion	146.491	0.00340[1]		11.491
Bottom:	impact followed by coupled motion	194.179	0.00382		19.179
	maximum return motion (coupled)	193.776	0.00404		18.776
	start of free motion	206.789	0.00622		31.789
Top:	impact followed by coupled motion	135.416	0.00665		40.416
	maximum return motion (coupled)	133.957	0.00711		38.957
	start of free motion	146.743	0.01065[2]	0.00725[3]	51.743
Bottom:	impact followed by coupled motion	193.636	0.01104		58.636
	maximum return motion (coupled)	193.083	0.01129		58.083
	start of free motion	207.171	0.01354		72.171
Top:	impact followed by coupled motion	135.168	0.01395		80.168
	maximum return motion (coupled)	133.504	0.01443		78.504
	start of free motion	146.383	0.01795[4]	0.00730[5]	91.383
Bottom:	impact followed by coupled motion	194.198	0.01837		99.198
	maximum return motion (coupled)	193.698	0.01861		98.698
	start of free motion	206.601	0.02077		111.601
Top:	impact followed by coupled motion	135.600	0.02121		120.600
	maximum return motion	134.171	0.02167		119.171
	start of free motion	146.856	0.02521[6]	0.00725[7]	131.856

[1] Start of first cycle
[2] End of first cycle, start of second cycle
[3] Time interval for first cycle
[4] End of second cycle, start of third cycle
[5] Time interval for second cycle
[6] End of third cycle
[7] Time interval for third cycle

Table 4. Maximum reversal angles and associated values of g for standard configuration with $\mu = .3$ and $\varepsilon = 0$ (Program No. 70)

	Top action		Bottom action	
Cycle No.	Maximum reversal angle, φ ($\varphi_M = 132.487°$)	g (in.) ($g_M = -.05467$)	Maximum reversal angle, φ ($\varphi_M = 187.518°$)	g^1 (in.) ($g_M = -.05467$)
1			193.776	-.0401 (-.1019 cm)
2	133.957	-.0495 (-.1257 cm)	193.083	-.0418 (-.1062 cm)
3	133.504	-.0512 (-.1300 cm)	193.698	-.0403 (-.1024 cm)
4	134.171	-.0487 (-.1237 cm)	192.883	-.0423 (-.1074 cm)
5	133.466	-.0513 (-.1303 cm)	193.659	-.0404 (-.1026 cm)
6	134.170	-.0487 (-.1237 cm)	192.883	-.0423 (-.1074 cm)
7	133.466	-.0513 (-.1303 cm)	193.659	-.0404 (-.1026 cm)
8	134.170	-.0487 (-.1237 cm)	192.884	-.0423 (-.1074 cm)

INFLUENCE OF VARIOUS PARAMETER CHANGES ON THE TOTAL FUZE TIME

The following reports on the results of numerous computer runs in which a single input or geometric parameter was varied in order to determine its influence on the total fuze time. In all cases, the individual changes were made with respect to the standard configuration in the section on the example mechanism, with $\mu = .3$ and $\varepsilon = .25$.

Influence of Escape-Wheel Torque

Figure 8 shows the influence of the escape-wheel torque on the fuze time. One may compare these timing results with those obtained from the well-known empirical expression:

$$t_2 = t_1 \sqrt{\frac{T_1}{T_2}}$$

If t_1 and T_1 represent fuze time and torque, respectively, as associated with the standard configuration, one obtains from the above:

For $T_2 = .75\ T_1$: $\quad t_2 = 2.79 \sqrt{\frac{1}{1.25}} = 3.22$ seconds

For $T_2 = 1.25\ T_1$ $\quad t_2 = 2.79 \sqrt{\frac{1}{1.25}} = 2.49$ seconds

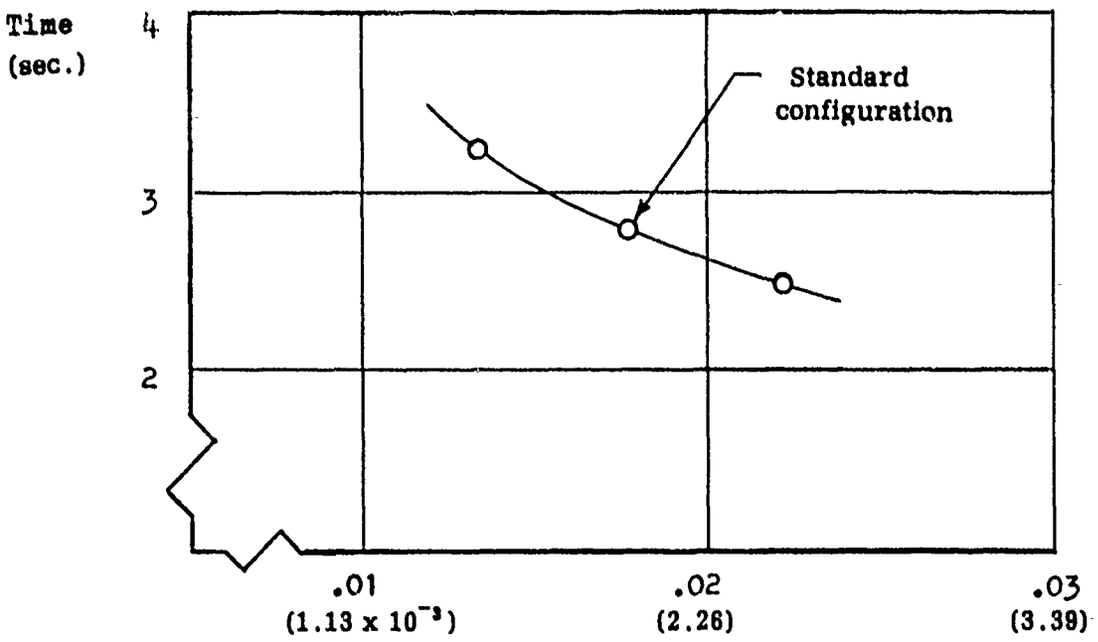
The results of the simulation (runs 47 and 48 of table of figure 8) show excellent agreement with the above. The empirical relationship has been confirmed time and again by experiment.

Influence of Pallet Moment of Inertia

Figure 9 shows that the total fuze delay time increases with an increase of the pallet moment of inertia. The ratio of any two fuze periods is approximately proportional to the ratio of the square roots of the associated pallet inertias. These results are confirmed by the experiments of Anderson and Redmond (ref. 7).

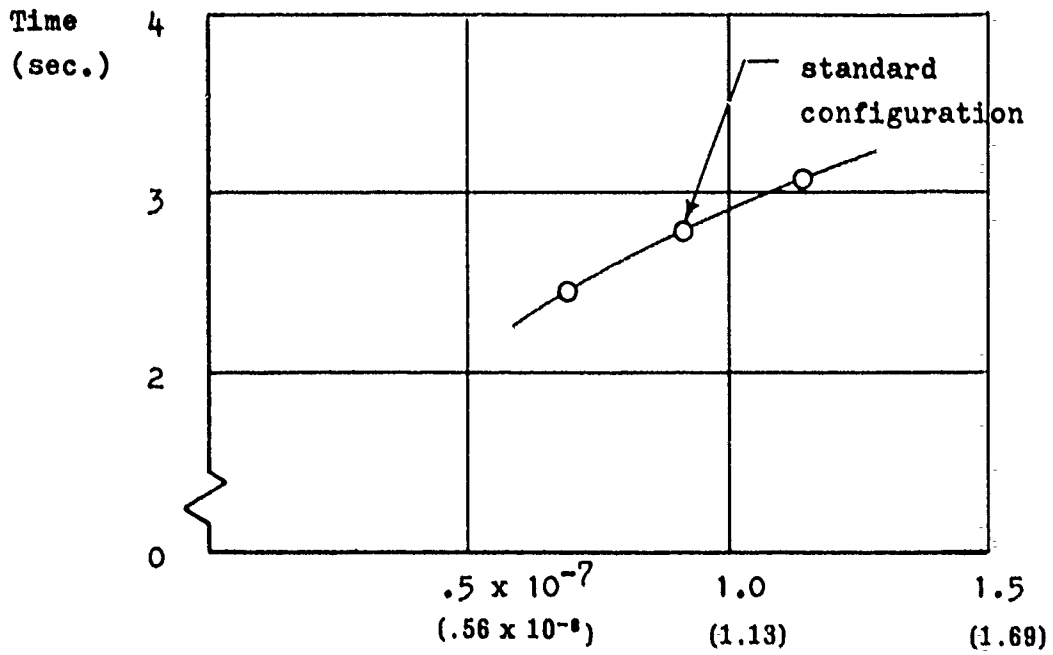
Influence of Pallet Escape-Wheel Center Distance

Figure 10 indicates, for the range explored, that the fuze time increases as the center distance a is increased. For a total increase of .007 inches (.018 cm), the time increase is approximately 7%. This result is



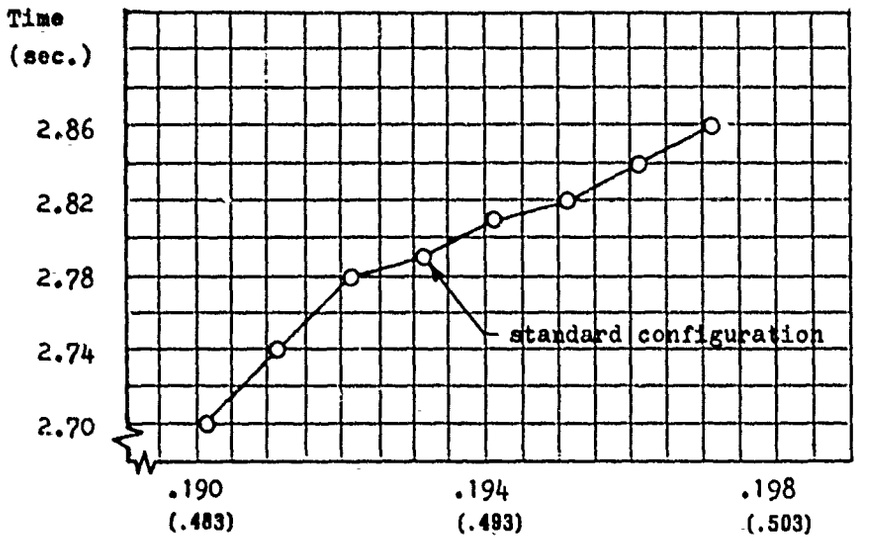
Run no.	Torque (lb-in.)	Total Fuze Time (sec.)
48	.0133 (75% of St.) (1.503 x 10^{-3} m-N)	3.23
46	.0177 (St.) (2.000 x 10^{-3} m-N)	2.79
47	.0221 (125% of St.) (2.497 x 10^{-3} m-N)	2.50

Figure 8. Influence of escape-wheel torque on fuze delay time



Run no.	Moment of inertia of pallet (lb-sec^2-in)	Total fuze time (sec.)
57	.68 x 10^{-7} (7.68 x 10^{-9} N-m-sec^2)	2.46
46	.91 x 10^{-7} (std. conf.) (1.027 x 10^{-8} N-m-sec^2)	2.79
58	1.137 x 10^{-7} (1.283 x 10^{-8} N-m-sec^2)	3.07

Figure 9. Influence of pallet moment of inertia on fuze delay time



Run no.	Center distance "a" (in.)	Total fuze time (sec.)
55	.1901 (.4829 cm)	2.70
54	.1911 (.4854 cm)	2.74
53	.1921 (.4879 cm)	2.78
46	.1931 (std. conf.) (.4905 cm)	2.79
49	.1941 (.4930 cm)	2.81
50	.1951 (.4956 cm)	2.82
51	.1961 (.4981 cm)	2.84
52	.1971 (.5006 cm)	2.86

Figure 10. Influence of pallet escape-wheel center distance on fuze delay time

generally confirmed by the experimentation of Anderson and Redmond (ref. 7), where it is shown that an increase of time is effected as the center distance is increased from a dimension somewhat below nominal.

Influence of Pallet Radius

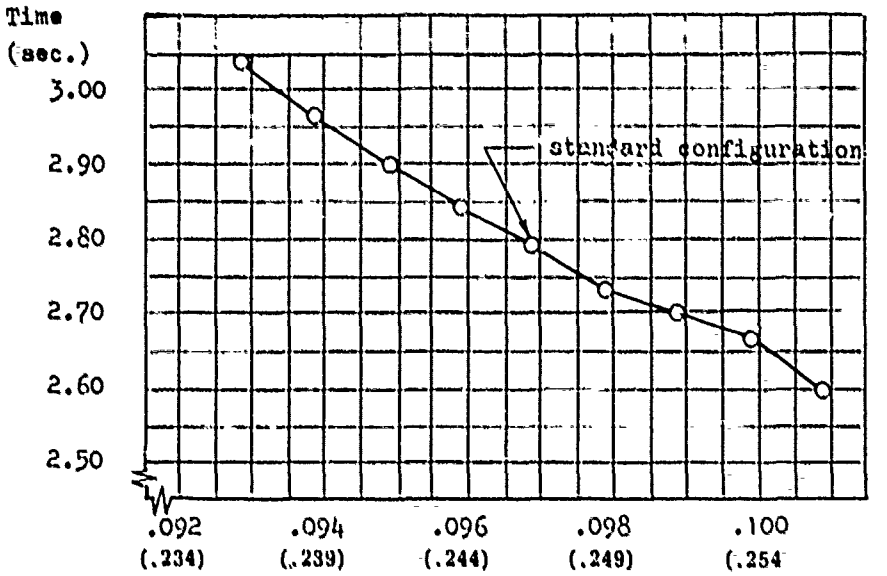
Figure 11 shows a continuous and quite dramatic decrease in fuze period as the pallet radius c is increased by .008 inches (.020 cm). It is believed that this effect is similar to that observed in connection with a decrease in center distance a, i.e. an increase in pallet radius represents an effective decrease of center distance. The experimentation performed in reference 7 gives good correlation with this result of the simulation.

Influence of Coefficient of Friction

Figure 12 indicates that the fuze time increases as the coefficient of friction, associated with coupled motion, is increased. One would expect that an increase of energy dissipation will slow the mechanism.

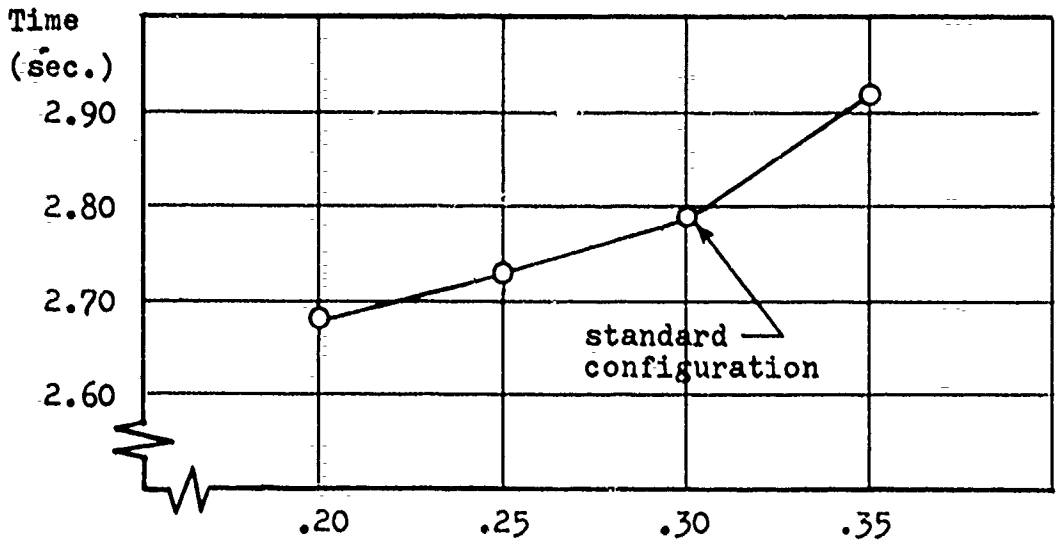
Influence of Coefficient of Restitution

According to figure 13, the fuze time increases considerably as the coefficient of restitution is varied from completely inelastic to partially elastic; i.e. from zero to .5. When $\varepsilon = 0$ (see description of run no. 70 in the section on results for standard configuration), coupled motion follows immediately after impact. In run no. 75 (which is not reproduced in this report), where $\varepsilon = .5$, top action consists of four impacts, three of which are followed by free motion while the fourth is followed by coupled motion. Bottom action shows two impacts with the last one followed by coupled motion. Each of the impacts is followed by considerable escape-wheel reversal. These multiple impacts and associated motion reversals seem to account for the observed increase in fuze time.



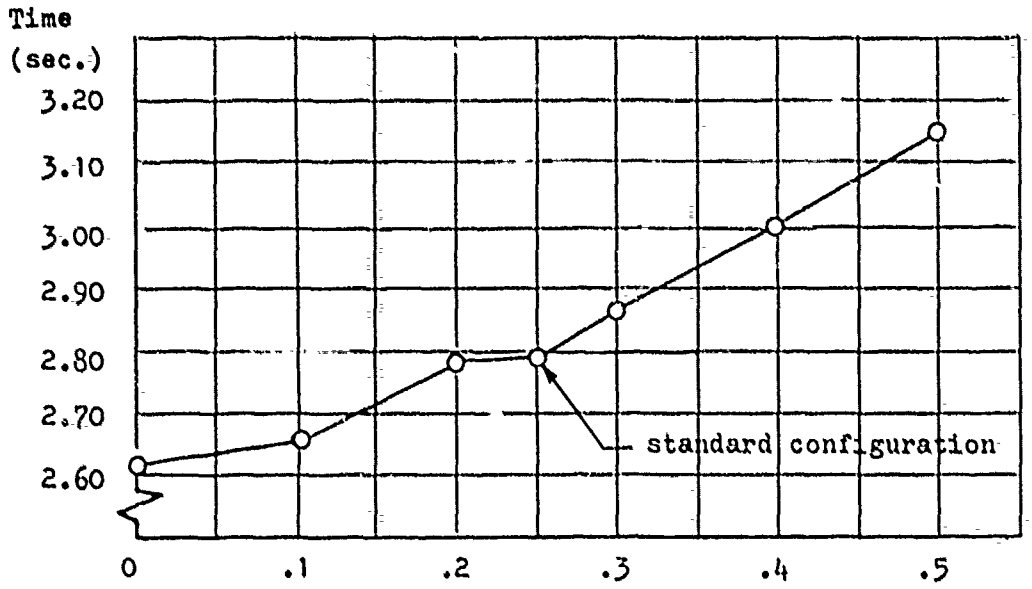
Run no.	Pallet radius "c" (in.)	Total fuze time (sec.)
66	.0928 (.2357 cm)	3.04
65	.0938 (.2383 cm)	2.97
64	.0948 (.2408 cm)	2.90
63	.0958 (.2433 cm)	2.84
46	.0968 (std. conf.) (.2459 cm)	2.79
59	.0978 (.2489 cm)	2.73
60	.0988 (.2510 cm)	2.70
61	.0998 (.2535 cm)	2.67
62	.1008 (.2560 cm)	2.60

Figure 11. Influence of pallet radius on fuze delay time



Run no.	Coefficient of friction, μ	Total fuze time (sec.)
68	.20	2.68
67	.25	2.73
46	.30 (std. conf.)	2.79
69	.35	2.92

Figure 12. Influence of coefficient of friction of coupled motion on fuze delay time



Run no.	Coefficient of restitution, ε	Total fuze time (sec.)
75	.5	3.15
74	.4	3.01
73	.3	2.87
46	.25 (std. conf.)	2.79
72	.2	2.78
71	.1	2.66
70	0.0	2.62

Figure 13. Influence of coefficient of restitution on fuze delay time

DISCUSSION AND RECOMMENDATIONS FOR CONTINUED WORK

There is no doubt that the goal of a workable computer simulation of the pin pallet runaway escapement has been attained. This is mainly due to the fact that every effort was made to keep the program and its controls as simple as possible.

As a consequence of this, there is presently no built-in sensing mechanism that indicates whether the pallet pin makes contact with the backside of an adjacent tooth during free motion. While this abnormality did not occur for the M525 mechanism, there is no assurance that it will never occur.

Secondly, there is the unresolved problem of the somewhat excessive escape-wheel reversal for the standard configuration unless fairly unrealistic values are used for the coefficients of friction and restitution. (Recall the discussion in the section on the results for the standard configuration.) Table 5 shows the extent to which this escape-wheel reversal depends on the center distance between the pallet and escape-wheel pivots.

Clearly, the reversal increases with a decrease in center distance and decreases as the center distance is enlarged. Note, that for a = .1941 inches (.4930 cm), which is .001 in (.0025 cm) above nominal, $|g| < |g_{MAX}|$. Note further, that the disengagement center distance of .208 inches (.528 cm) (see end of the section on the example mechanism) is much larger than the values which have been explored in table 5.

Excessive escape-wheel reversal may be indicative of the fact that the simple impact formulation is not sufficiently descriptive, as shown by Anderson and Redmond (ref. 7) or that the escapement only operates in the expected manner when the center distance is somewhat enlarged from nominal.

To resolve this problem, high speed motion pictures must be taken in order to be able to observe the actual motion. Following this, certain modifications of the impact model may have to be made.

Even if the question of the motion reversal cannot be fully resolved, the present simulation is sufficiently descriptive to undertake the following extensions:

1. Adaptation of the pin pallet runaway escapement simulation to a centrifugally driven mechanism, such as the M577 safe separation device (SSD).[6]

2. Adaptation of the pin pallet simulation to a spring-driven timing mechanism.

3. Modification of the present model to accommodate the simulation of a plate pallet (verge) type runaway escapement.

---

[6] Successful simulations, incorporating the present escapement model, of both the M577 SSD and the M125A1 booster have been recently completed. The results will be given in a future report.

Table 5. Escape-wheel reversal as a function of center distance a

Center distance, a* (in.)	Value of g at maximum reversal during top action (in.)	Program number
.1901 (.4829 cm)	-.0662 (-.1681 cm)	55
.1911 (.4854 cm)	-.0635 (-.1613 cm)	54
.1921 (.4879 cm)	-.0600 (-.1524 cm)	53
.1931 (std. conf.) (.4905 cm)	-.0580 (-.1473 cm)	46
.1941 (.4930 cm)	-.0536 (-.1361 cm)	49
.1951 (.4956 cm)	-.0520 (-.1321 cm)	50
.1961 (.4981 cm)	-.0471 (-.1196 cm)	51
.1971 (.5006 cm)	-.0441 (-.1120 cm)	52

*Dimension a is variable, otherwise dimensions are standard configuration with $\mu = .3$, $\varepsilon = .25$ and $g_{MAX} = -.05467$ in. (-.13886 cm).

REFERENCES

1. "A Study of the Dynamics of an Untuned Clock Mechanism," Contract No. CST-1224 with NBS, Department of Physics, Virginia Military Institute, Lexington, VA, September 1953

2. "A Study of the Effect of Geometrical Factors upon the Behavior of an Untuned Clock Mechanism," Contract No. CST-1224 with Harry Diamond Ordnance Fuze Laboratories, Department of Physics, Virginia Military Institute, Lexington, VA, June 30, 1954

3. "A Study of the Non-Uniformity in Running Rates of a Certain Type of Time Delay Mechanisms," Contract No. DAI-49-186-502-ORD(P)-186 with Harry Diamond Ordnance Fuze Laboratories, Department of Physics, Virginia Military Institute, Lexington, VA, August 31, 1954

4. "The Effect of Unbalanced Verge Torques, Acceleration Friction Torques, and Verge-Starwheel Material upon Running Rates of Certain Time Delay Mechanisms," Contract No. DAI-49-186-502-ORD(P)-186 with Harry Diamond Ordnance Fuze Laboratories, Department of Physics, Virginia Military Institute, Lexington, VA, January 1955

5. "Part I: An Untuned Clock Mechanism of Special Design. Part II: An Experimental Study of the Motion of an Untuned Clock," Contract No. DAI-49-186-502-ORD(P)-186 with Harry Diamond Ordnance Fuze Laboratories, Department of Physics, Virginia Military Institute, Lexington, VA, June 1956

6. "Untuned Escapements" Session 5, Picatinny Arsenal Horology Familiarization Course, Bulova Watch Co., Valley Stream, NY

7. M. E. Anderson and S. L. Redmond, "Runaway (Verge) Escapement Analysis and Guide for Designing Fuze Escapements," NWCCL TP 860, Naval Weapons Center, Corona Laboratory, Corona, CA 91720, December 1969

8. R. X. Brennan, "Several New Mathematical Models Incorporated into the Picatinny Arsenal Version of the NWCCL Runaway Escapement Digital Program,"Information Report No. 50, Fuze Development Branch, Picatinny Arsenal, Dover, NJ 07801, October 1973

9. L. P. Farace, "Runaway Escapement Redesign-M125A1 Modular Booster," FA-TR-74045, Frankford Arsenal, Philadelphia, PA 19137, December 1974

10. W. Goldsmith, "Impact-The Theory and Physical Behaviour of Colliding Solids," Edward Arnold (Publishers) Ltd, London, England, 1960

11. G. W. Hemp, "Dynamic Analysis of the Runaway Escapement Mechanism," The Shock and Vibration Bulletin, Bulletin No. 42, Naval Research Laboratories, Washington, DC, January 1972

12. W. Horenstein, "Summary of Reports on an Untuned Clock Mechanism," Technical Memorandum, Diamond Ordnance Fuze Laboratory, Washington, DC 20438, December 1954

13. D. L. Overman, "Analysis of M125 Booster Mechanism," HDL-TR-1550, Harry Diamond Laboratories, Washington, DC 20438, June 1971

14. J. N. Shinkle, "A General Study of Verge Escapement Performance," SC-RR-69-495, Sandia Laboratories, Albuquerque, NM, October 1969

15. J. P. Sirpal, "Rocker Mechanisms," Institution of Engineers (India), Vol 45, No. 5, pp 132-138, January 1965

APPENDIX A

KINEMATICS OF COUPLED MOTION

Figure A1 shows the kinematic relationship of the escape-wheel and the pallet during coupled motion.

UNIT VECTORS

The unit vectors $\bar{n}_t$ and $\bar{n}_n$ are along and perpendicular to the contact surface of the escape-wheel tooth in the indicated directions, respectively. Thus,

$$\bar{n}_t = \cos(\varphi - \alpha)\,\bar{i} + \sin(\varphi - \alpha)\,\bar{j} \qquad \text{(A1)}$$

$$\bar{n}_n = -\sin(\varphi - \alpha)\,\bar{i} + \cos(\varphi - \alpha)\,\bar{j} \qquad \text{(A2)}$$

In addition, the unit vectors $\bar{n}_b$, for the escape-wheel, and $\bar{n}_c$, for the line connecting the pallet pivot and the center of the pallet pin, are introduced:

$$\bar{n}_b = \cos\varphi\,\bar{i} + \sin\varphi\,\bar{j} \qquad \text{(A3)}$$

$$\bar{n}_c = \cos\psi\,\bar{i} + \sin\psi\,\bar{j} \qquad \text{(A4)}$$

INPUT - OUTPUT RELATIONSHIP

The mechanism loop equation is used to determine the pallet angle ψ and the pallet pin location g with respect to the tip of the escape-wheel as functions of the escape-wheel angle φ and the applicable mechanism constants, i.e.

$$O = b(\cos\varphi\,\bar{i} + \sin\varphi\,\bar{j}) + g[\cos(\varphi - \alpha)\bar{i} + \sin(\varphi - \alpha)\bar{j}] + r[-\sin(\varphi - \alpha)\bar{i} + \cos(\varphi - \alpha)\bar{j}] - c(\cos\psi\,\bar{i} + \sin\psi\,\bar{j}) + a\,\bar{i} \qquad \text{(A5)}$$

The above is rewritten in component form:

$$b\cos\varphi + g\cos(\varphi - \alpha) - r\sin(\varphi - \alpha) - c\cos\psi + a = O \qquad \text{(A6)}$$

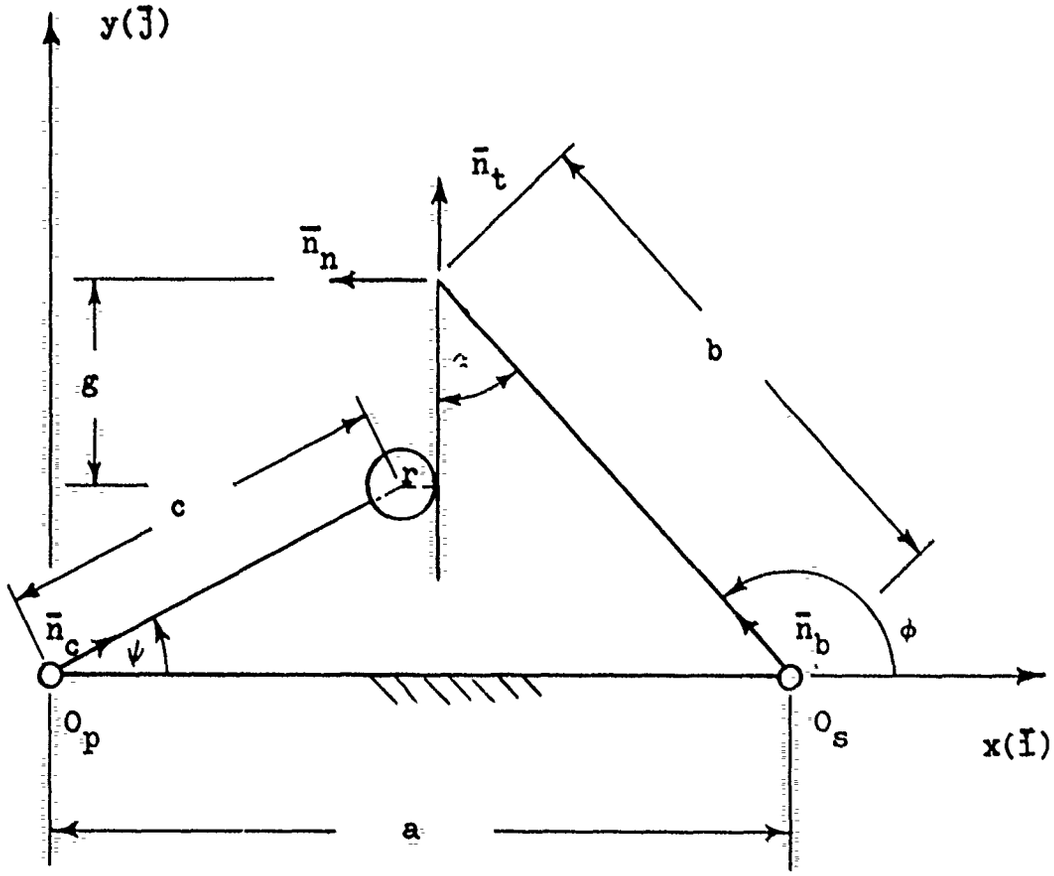


Figure A1. Coupled motion kinematics

$$b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha) - c \sin \psi = 0 \quad \text{(A7)}$$

The angle ψ is obtained from (A7):

$$\sin \psi = \frac{1}{c} [b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha)] \quad \text{(A8)}$$

and

$$\cos \psi = \frac{1}{c} \sqrt{c^2 - [b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha)]^2} \quad \text{(A9)}$$

Substitution of equation (A9) into equation (A6) and subsequent squaring of both sides of the resulting expression leads to:

$$[b \cos \varphi + g \cos(\varphi - \alpha) - r \sin(\varphi - \alpha) + a]^2 = c^2 - [b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha)]^2 \quad \text{(A10)}$$

Rearrangement gives:

$$g^2 + g[2b \cos \alpha + 2a \cos(\varphi - \alpha)] + [a^2 + b^2 + r^2 - c^2 + 2br \sin \alpha + 2ab \cos \varphi - 2ar \sin(\varphi - \alpha)] = 0 \quad \text{(A11)}$$

Finally, solution of equation (A11) leads to:

$$g = \frac{-H + \sqrt{H^2 - 4K}}{2} \quad \text{(A12)}$$

where

$$H = 2[b \cos \alpha + a \cos(\varphi - \alpha)] \quad \text{(A13)}$$

$$K = a^2 + b^2 + r^2 - c^2 + 2br \sin \alpha + 2ab \cos \varphi - 2ar \sin(\varphi - \alpha) \quad \text{(A14)}$$

The correct value of g, as obtained from equation (A12), must have the smaller absolute magnitude.

OUTPUT VELOCITIES

Implicit differentiation of equation (A11) furnishes the velocity $\dot{g}$ of the instantaneous contact point on the pallet with respect to the coincident point on the escape-wheel during coupled motion:

$$\dot{g} = \frac{a\,P}{S}\ \dot{\varphi} \tag{A15}$$

where

$$P = b\sin\varphi + g\sin(\varphi - \alpha) + r\cos(\varphi - \alpha) \tag{A16}$$

$$S = g + b\cos\alpha + a\cos(\varphi - \alpha) \tag{A17}$$

Differentiation of equation (A8) leads to the pallet angular velocity during coupled motion:

$$\dot{\psi} = \frac{Q\dot{\varphi} + \dot{g}\sin(\varphi - \alpha)}{(c)\cos\psi} \tag{A18}$$

where

$$Q = b\cos\varphi + g\cos(\varphi - \alpha) - r\sin(\varphi - \alpha) \tag{A19}$$

OUTPUT ACCELERATIONS

Differentiation of equation (A15) results in an expression for the relative acceleration of the contact point on the pallet with respect to that on the escape-wheel:

$$\ddot{g} = \frac{\ddot{\varphi}\,Pa + \dot{\varphi}^2\,Qa + 2\dot{\varphi}\,\dot{g}\,a\,\sin(\varphi - \alpha) - \dot{g}^2}{S} \tag{A20}$$

Further, differentiation of equation (A18) furnishes an expression for the angular acceleration of the pallet during coupled motion:

$$\ddot{\psi} = \frac{\ddot{\varphi}\,Q - \dot{\varphi}^2 P + 2\dot{g}\,\dot{\varphi}\cos(\varphi - \alpha) + \ddot{g}\,\sin(\varphi - \alpha)}{c\cos\psi}$$

$$+ \dot{\psi}^2\tan\psi \tag{A21}$$

APPENDIX B

DIFFERENTIAL EQUATION OF COUPLED MOTION

Figure B-1 shows free body diagrams of the pallet and escape-wheel, as they are found during coupled motion. The torque T acts on the escape-wheel. The forces between the escape-wheel and the pallet are represented by the normal forces $\pm\bar{P}_n$ in the direction of $\bar{n}_n$ and the friction forces $\pm(\bar{\mu P}_n)$ in the direction of $\bar{n}_t$. The sign of the friction forces must be such that when the contact point K on the pallet pin moves in the direction of the positive velocity $\dot{g}$ with respect to the coincident point L on the escape-wheel, the friction force on the pallet pin must act in the negative direction of $\dot{g}$. (Note that $\dot{g}$, as given by equation (A15) in appendix A, has the same direction as the relative velocity $\bar{V}_{K/L}$.)

The frictional resistance at the pivots O_p and O_s is neglected, since the pivot radii are commonly held very small causing the friction moments to become insignificant.

The differential equations of rotation will first be written separately for the pallet and the escape-wheel. Since the output angle ψ is a function of the input angle φ throughout coupled motion, both expressions may be combined by way of the common force magnitudes.

Equation of Motion for the Pallet

$$\bar{D}_1 \times P_n\bar{n}_n + \bar{C}_1 \times (-\mu P_n \frac{\dot{g}}{|\dot{g}|})\bar{n}_t = I_p\ddot{\psi}\bar{k} \qquad \text{(B1)}$$

Equation of Motion for the Escape-Wheel

$$\bar{A}_1 \times (-\bar{P}_n)\bar{n}_n + \bar{B}_1 \times (\mu P_n \frac{\dot{g}}{|\dot{g}|})\bar{n}_t + T\bar{k} = I_s\ddot{\varphi}\bar{k} \qquad \text{(B2)}$$

The moment arms $\bar{A}_1$, $\bar{B}_1$, $\bar{C}_1$, and $\bar{D}_1$ are given by equations (C6), (C7), (C4), and (C5), respectively. I_p and I_s represent the moments of inertia of the pallet and the escape-wheel with respect to their pivots.

Appropriate vector operations on equations (B1) and (B2) furnish the following scalar expressions:

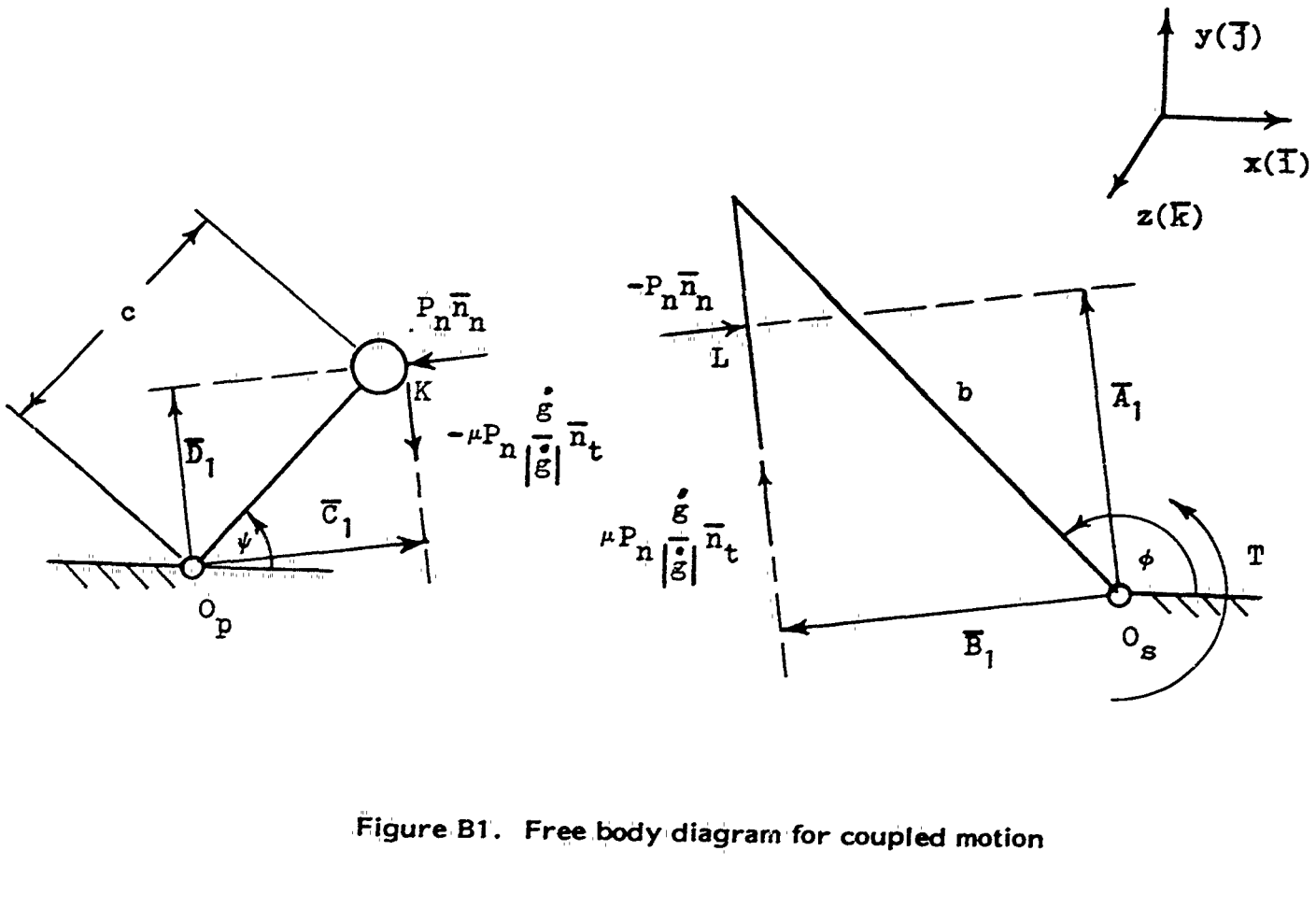


Figure B1. Free body diagram for coupled motion

$$P_n (D_1 - C_1 \mu \frac{\dot{g}}{|\dot{g}|}) = I_p \ddot{\psi} \tag{B3}$$

and

$$-P_n (A_1 + B_1 \mu \frac{\dot{g}}{|\dot{g}|}) + T = I_s \ddot{\varphi} \tag{B4}$$

When the above expressions are equated in terms of $\bar{P}_n$, one obtains:

$$\frac{I_p (A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|})}{(D_1 - \mu C_1 \frac{\dot{g}}{|\dot{g}|})} \ddot{\psi} + I_s \ddot{\varphi} = T \tag{B5}$$

The angular acceleration $\ddot{\psi}$ is now expressed in terms of $\ddot{\varphi}$ and $\dot{\varphi}$ with the help of equation (A21) of appendix A. Equations (A15), (A18), and (A20) are utilized to replace $\dot{g}$, $\ddot{\psi}$ and $\ddot{g}$, respectively. After considerable simplification, one obtains the following expression for $\ddot{\psi}$:

$$\ddot{\psi} = U \ddot{\varphi} + V \dot{\varphi}^2 \tag{B6}$$

where

$$U = \frac{Q + \frac{ap}{S} \sin(\varphi - \alpha)}{(c) \cos \psi} \tag{B7}$$

and

$$V = \frac{1}{c \cos \varphi} \left[\frac{2aP}{S} \cos(\varphi - \alpha) - P + \frac{2a^2 P}{S^2} \sin^2 (\varphi - \alpha) + \frac{aQ}{S} \sin(\varphi - \alpha) - \frac{a^2 P^2}{S^3} \sin(\varphi - \alpha) \right] + \frac{\tan \psi}{c^2 \cos^2 \psi} \left[Q + \frac{Pa}{S} \sin(\varphi - \alpha) \right]^2 \tag{B8}$$

Equation (B6) is now substituted into equation (B5). This results in:

$$\left[I_p U \frac{\left(A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|} \right)}{\left(D_1 - \mu C_1 \frac{\dot{g}}{|\dot{g}|} \right)} + I_s \right] \ddot{\varphi} + I_p V \frac{\left(A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|} \right)}{\left(D_1 - C_1 \frac{\dot{g}}{|\dot{g}|} \right)} (\dot{\varphi})^2$$

$$= T \qquad \text{(B9)}$$

For computational purposes, equation (B9) is rewritten in the following form:

$$\ddot{\varphi} + W\dot{\varphi}^2 = Y \qquad \text{(B10)}$$

where

$$W = \frac{\frac{I_p V}{E_1}}{\frac{I_p U}{E_1} + \frac{I_s}{F_1}} \qquad \text{(B11)}$$

$$Y = \frac{\frac{T}{F_1}}{\frac{I_p U}{E_1} + \frac{I_s}{F_1}} \qquad \text{(B12)}$$

and

$$E_1 = D_1 - \mu C_1 \frac{\dot{g}}{|\dot{g}|} \qquad \text{(B13)}$$

$$F_1 = A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|} \qquad \text{(B14)}$$

APPENDIX C

MOMENT ARMS

DETERMINATION OF MOMENT ARMS $\bar{C}_1$ AND $\bar{D}_1$

Figure C-1 suggests the following loop equation for the determination of the vectors $\bar{C}_1$ and $\bar{D}_1$:

$$c\bar{n}_c - r\bar{n}_n - D_1\bar{n}_n + C_1\bar{n}_n = 0 \tag{C1}$$

When the components in the $\bar{n}_t$ and $\bar{n}_n$ directions are separated, one obtains:

$$c\cos\psi + r\sin(\varphi - \alpha) + D_1\cos(\varphi - \alpha) - C_1\sin(\varphi - \alpha) = 0 \tag{C2}$$

and

$$c\sin\psi - r\cos(\varphi - \alpha) + D_1\sin(\varphi - \alpha) + C_1\cos(\varphi - \alpha) = 0 \tag{C3}$$

Simultaneous solution of the above expressions leads to the following vectorial expressions:

$$\bar{C}_1 = -[r + c\sin(\varphi - \alpha - \psi)]\bar{n}_n \tag{C4}$$

and

$$\bar{D}_1 = c\cos(\varphi - \alpha - \psi)\bar{n}_t \tag{C5}$$

DETERMINATION OF MOMENT ARMS $\bar{A}_1$ AND $\bar{B}_1$

Inspection of figure C-1 leads to the following expressions for the vectors $\bar{A}_1$ and $\bar{B}_1$:

$$\bar{A}_1 = (b\cos\alpha + g)\bar{n}_t \tag{C6}$$

(Note that g is negative during contact.)

Further,

$$\bar{B}_1 = (b\sin\alpha)\bar{n}_n \tag{C7}$$

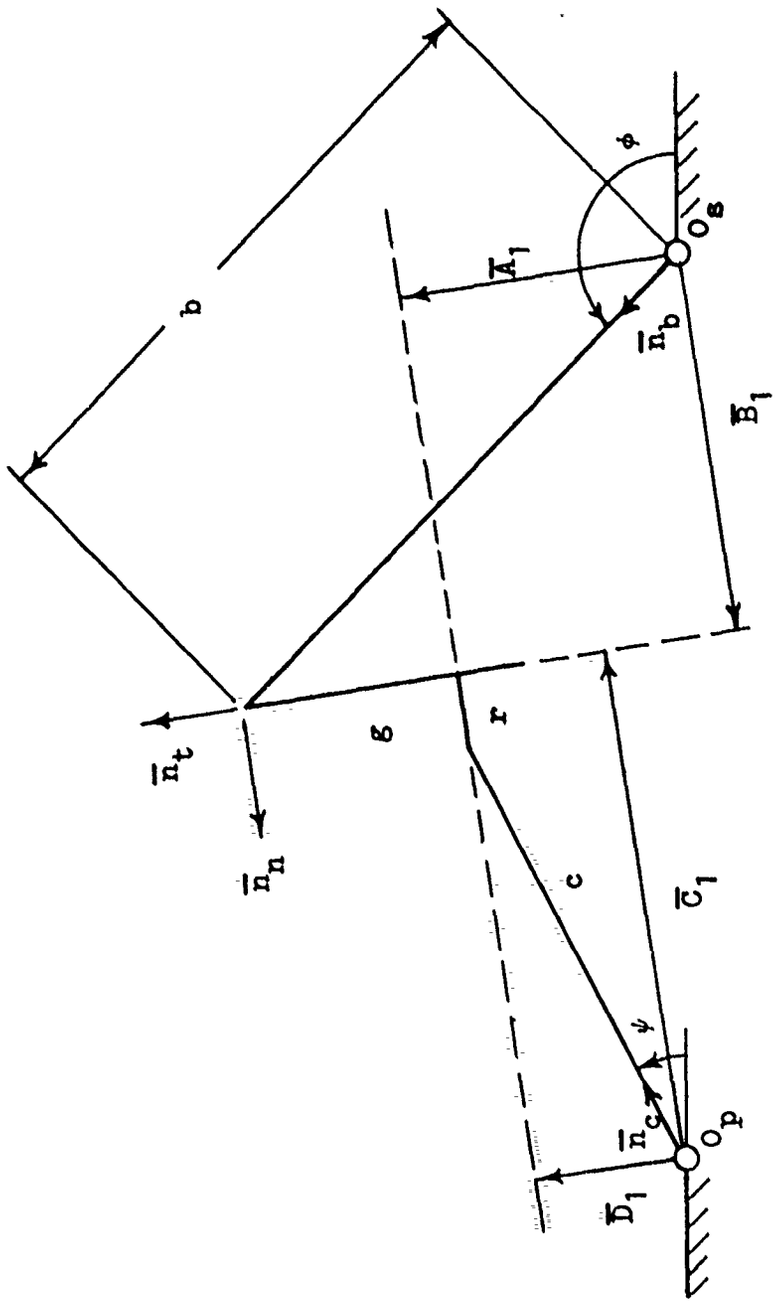


Figure C1. Moment arms

APPENDIX D

CONTACT SENSING EXPRESSIONS

When the mechanism is in free motion, i.e. φ and ψ are independent of each other, it is necessary to know the distances f and g', in figure D-1, to determine the relative positions. The quantity f, which indicates the distance of the pallet pin from the escape-wheel face, vanishes at the instant of impending impact. When contact between the pallet and the escape-wheel becomes impossible, i.e. the pin has left the tooth, $g' \geq 0$.

By inspection of figure D-1, the loop equation for free motion is given by:

$$b\bar{n}_b + g'\bar{n}_t + (r + f)\bar{n}_n - c\bar{n}_c + a\bar{i} = 0 \qquad (D1)$$

(Note that φ and ψ are independent variables and are assumed to be known.)

In component form, the above becomes:

$$b\cos\varphi + g'\cos(\varphi - \alpha) - r\sin(\varphi - \alpha) - f\sin(\varphi - \alpha) - c\cos\psi + a = 0 \qquad (D2)$$

$$b\sin\varphi + g'\sin(\varphi - \alpha) + r\cos(\varphi - \alpha) + f\cos(\varphi - \alpha) - c\sin\psi = 0 \qquad (D3)$$

Multiply equation (D2) by $\sin(\varphi - \alpha)$

$$b\cos\varphi\sin(\varphi - \alpha) + g'\sin(\varphi - \alpha)\cos(\varphi - \alpha) - r\sin^2(\varphi - \alpha) - f\sin^2(\varphi - \alpha) - c\cos\psi\sin(\varphi - \alpha) + a\sin(\varphi - \alpha) + a\sin(\varphi - \alpha) = 0 \qquad (D4)$$

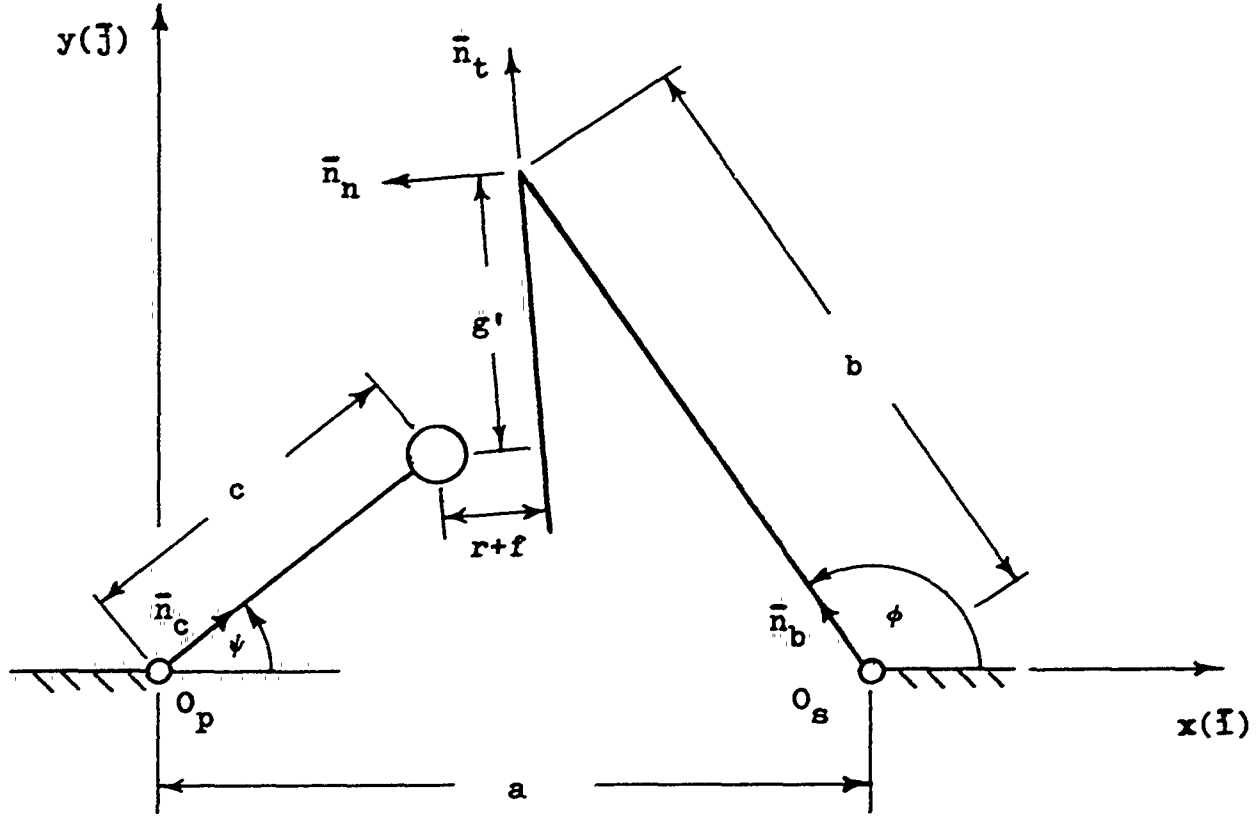


Figure D1. Contact sensing quantities

Further, multiply equation (D3) by $\cos(\varphi - \alpha)$

$$b\sin\varphi\cos(\varphi - \alpha) + g'\sin(\varphi - \alpha)\cos(\varphi - \alpha) + r\cos^2(\varphi - \alpha)$$
$$+ f\cos^2(\varphi - \alpha) - c\sin\psi\cos(\varphi - \alpha) \qquad (D5)$$
$$= 0$$

Subtract equation (D4) from equation (D5)

$$b\sin[\varphi - (\varphi - \alpha)] + r + f + c\sin[(\varphi - \alpha) - \psi] - a\sin(\varphi - \alpha)$$
$$= 0 \qquad (D6)$$

This furnishes

$$f = a\sin(\varphi - \alpha) - b\sin\alpha - c\sin[(\varphi - \alpha) - \psi] - r \qquad (D7)$$

Multiply (D2) by $\cos(\varphi - \alpha)$

$$b\cos\varphi\cos(\varphi - \alpha) + g'\cos^2(\varphi - \alpha) - r\sin(\varphi - \alpha)\cos(\varphi - \alpha)$$
$$- f\sin(\varphi - \alpha)\cos(\varphi - \alpha) - c\cos\psi\cos(\varphi - \alpha)$$
$$+ a\cos(\varphi - \alpha)$$
$$= 0 \qquad (D8)$$

Multiply (D3) by $\sin(\varphi - \alpha)$

$$b\sin\varphi\sin(\varphi - \alpha) + g'\sin^2(\varphi - \alpha) + r\sin(\varphi - \alpha)\cos(\varphi - \alpha)$$
$$+ f\sin(\varphi - \alpha)\cos(\varphi - \alpha) - c\sin\psi\sin(\varphi - \alpha)$$
$$= 0 \qquad (D9)$$

Finally, add (D8) and (D9)

$$b\cos[\varphi - (\varphi - \alpha)] + g' - c\cos[\psi - (\varphi - \alpha)] + a\cos(\varphi - \alpha)$$
$$= 0 \qquad (D10)$$

Thus,

$$g' = c\cos[(\varphi - \alpha) - \psi] - b\cos\alpha - a\cos(\varphi - \alpha) \qquad (D11)$$

APPENDIX E

FREE MOTION EQUATIONS

During the free motion phase of the mechanism, the pallet moves independently of the escape-wheel.

Again, the frictional resistance at the pivots O_p and O_s are neglected.

FREE MOTION OF PALLET

In the absence of all external torques, the differential equation of motion for the pallet is given by:

$$\ddot{\psi} = 0 \tag{E1}$$

With an initial angular velocity $\dot{\psi}_0$ at the time t_0, when the free motion starts, the angular velocity of the pallet at any time is:

$$\dot{\psi} = \dot{\psi}_0 \tag{E2}$$

If $\psi(t_0) = \psi_0$, further integration gives the angular displacement of the pallet at any time t to be:

$$\psi = \dot{\psi}_0 (t - t_0) + \psi_0 \tag{E3}$$

The time t is counted from the start of the motion of the escapement.

FREE MOTION OF THE ESCAPE-WHEEL

When a constant torque T acts on the escape-wheel, its differential equation of motion is given by:

$$\ddot{\varphi} = \frac{T}{I_s} \tag{E4}$$

and the applicable initial conditions are:

$$\dot{\varphi}(t_0) = \dot{\varphi}_0 \tag{E5}$$

and

$$\varphi(t_o) = \varphi_o \tag{E6}$$

Integration of equation (E4) gives the following expression for the angular velocity of the escape-wheel at any time t:

$$\dot{\varphi} = \frac{T}{I_s}(t - t_o) + \dot{\varphi}_o \tag{E7}$$

Further integration furnishes the angular displacement:

$$\varphi = \frac{T}{2I_s}(t - t_o)^2 + \dot{\varphi}_o(t - t_o) + \varphi_o \tag{E8}$$

APPENDIX F

IMPACT EQUATIONS

Before the impact equations can be given, certain velocity expressions associated with the impact points on the pallet and the escape-wheel must be derived. These velocities occur during free motion preceding impact when the angular velocities $\dot{\varphi}$ and $\dot{\psi}$ are independent of each other.

VELOCITIES AT IMPACT POINTS JUST BEFORE IMPACT

Figure F1 shows the velocities of the contact points K and L on the pallet and the escape-wheel, respectively, just before impact. The components in the direction normal to the escape-wheel tooth are:

$$\bar{V}_{pn_i} = \dot{\psi}_i \bar{k} \times D_1 \bar{n}_t \qquad \text{for the pallet} \qquad \text{(F1)}$$

and

$$\bar{V}_{sn_i} = \dot{\varphi}_i \bar{k} \times A_1 \bar{n}_t \qquad \text{for the escape-wheel,} \qquad \text{(F2)}$$

where the subscript i stands for the angular velocities prior to the instant of impact.

The components of velocity in the tangential direction are given by:

$$\bar{V}_{pt_i} = \dot{\psi}_i \bar{k} \times C_1 \bar{n}_n \qquad \text{(F3)}$$

and

$$\bar{V}_{st_i} = \dot{\varphi}_i \bar{k} \times B_1 \bar{n}_n \qquad \text{(F4)}$$

The expressions for the moment arms are obtained from appendix C.

To determine the direction of the tangential impact, the sign of the relative tangential velocity $\bar{V}_t$ must be known. This velocity is given by (refer to equations (F3) and (F4)):

$$\bar{V}_t = \bar{V}_{pt_i} - \bar{V}_{st_i} = \dot{\psi}_i \bar{k} \times C_1 \bar{n}_n - \dot{\varphi}_i \bar{k} \times B_1 \bar{n}_n \qquad \text{(F5)}$$

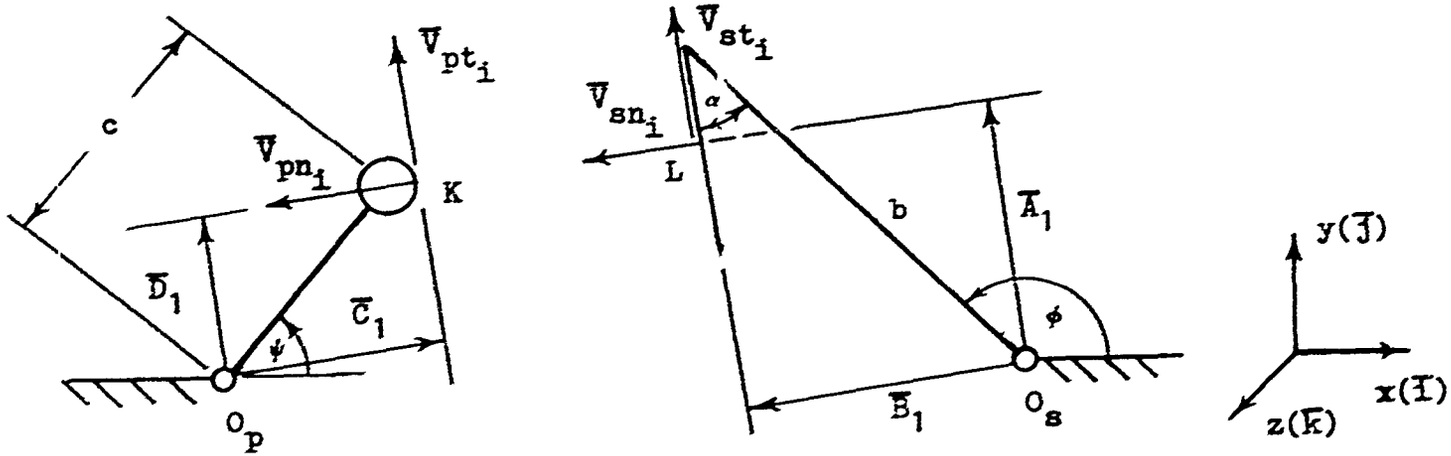


Figure F1. Velocities just before impact

Substituting equations (C4) and (C7) into equation (F5) produces:

$$\bar{V}_t = (\dot{\psi}[r + c\sin(\varphi - \alpha - \psi)] + \dot{\varphi}b\sin\alpha)\,\bar{n}_t \qquad (F6)$$

IMPACTS ON PALLET AND ESCAPE-WHEEL

The impact simulation is based on the classical angular impulse-momentum model shown in figure F-2 for the pallet and the escape-wheel.

$\bar{P}_n$ represents the normal impulse between the components. Further, a frictional impulse μP_n, which is tangential to the contact surface and has the direction of the velocity $\bar{V}_t$ (see equation (F6)), is assumed because of the angular displacements during impact.

The angular impulse T_τ on the escape-wheel, which is due to the torque T and has the duration τ of the impact phenomenon, is disregarded since it is felt that its magnitude is small when compared to that of the other terms involved. The angular impulse on the pallet then becomes:

$$\bar{J}_p = \bar{D}_1 \times P_n \bar{n}_n + \bar{C}_1 \times -\mu P_n \frac{\bar{V}_t}{|\bar{V}_t|}\,\bar{n}_t \qquad (F7)$$

After the cross product has been executed, the following equation is obtained:

$$\bar{J}_p = P_n (D_1 - \mu C_1 \frac{\bar{V}_t}{|\bar{V}_t|})\,\bar{k} \qquad (F8)$$

Similarly, the angular impulse on the escape-wheel reduces to:

$$\bar{J}_s = \bar{A}_1 \times (-P_n)\,\bar{n}_n + \bar{B}_1 \times \mu P_n \frac{\bar{V}_t}{|\bar{V}_t|}\,\bar{n}_t \qquad (F9)$$

This becomes

$$\bar{J}_s = -P_n (A_1 + \mu B_1 \frac{\bar{V}_t}{|\bar{V}_t|})\,\bar{k} \qquad (F10)$$

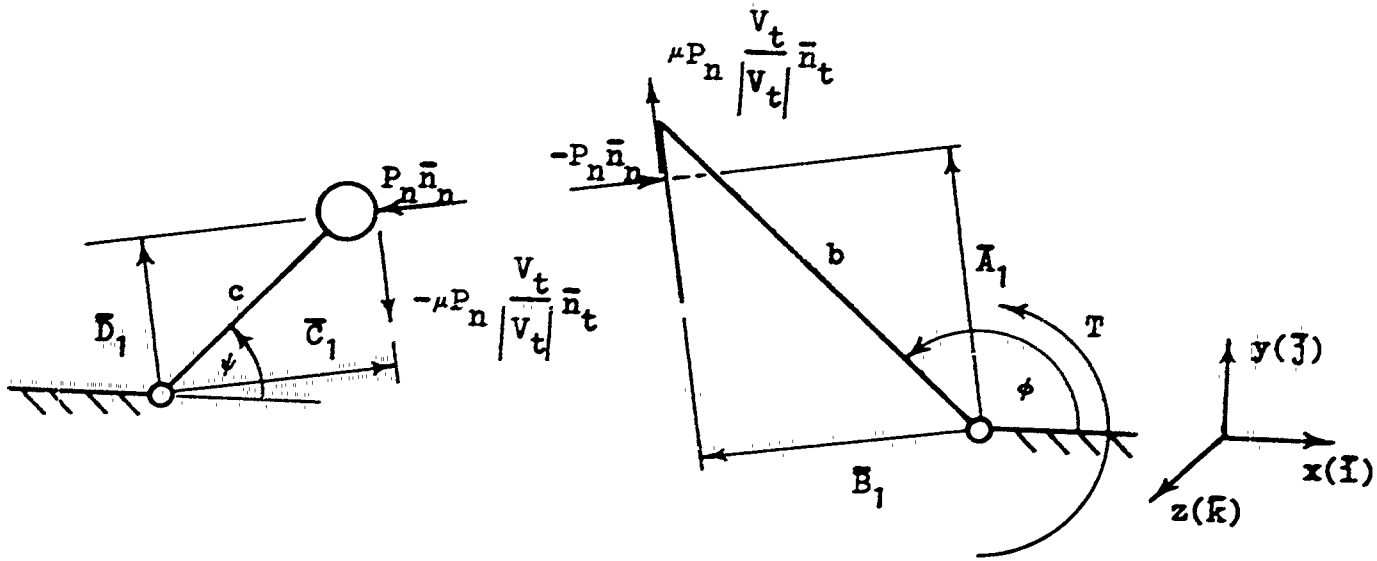


Figure F2. Free body diagram of impact

Equations (F8) and (F10) are now substituted into the following angular momentum equations:

$$I_p(\dot{\psi}_f - \dot{\psi}_i) = \bar{J}_p \tag{F11}$$

and

$$I_s(\dot{\varphi}_f - \dot{\varphi}_i) = \bar{J}_s \tag{F12}$$

The subscript f indicates the angular velocities after impact. Substitution of the scalar portions of equations (F8) and (F10) into equations (F11) and (F12), respectively, as well as the subsequent simultaneous elimination of P_n from both of the resulting expressions, leads to:

$$I_p F_2 \dot{\psi}_f + I_s E_2 \dot{\varphi}_f = I_p F_2 \dot{\psi}_i + I_s E_2 \dot{\varphi}_i \tag{F13}$$

where

$$E_2 = D_1 - \mu C_1 \frac{V_t}{|\bar{V}_t|} \tag{F14}$$

and

$$F_2 = A_1 + \mu B_1 \frac{V_t}{|\bar{V}_t|} \tag{F15}$$

To solve for the angular velocities after impact, it is now necessary to make use of the concept of the coefficient of restitution. This coefficient is adapted to the present situation in the following manner:

$$\varepsilon = - \frac{V_{pn_f} - V_{sn_f}}{V_{pn_i} - V_{sn_i}} \tag{F16}$$

Using equations (F1) and (F2) and letting

$$\bar{V}_{pn_f} = \dot{\psi}_f \bar{k} \times D_1 \bar{n}_t \qquad \text{for the pallet} \tag{F17}$$

$$\bar{V}_{sn_f} = \dot{\varphi}_f \bar{k} \times A_1 \bar{n}_t \qquad \text{for the escape-wheel} \qquad \text{(F18)}$$

where $\dot{\varphi}_f$ and $\dot{\psi}_f$ are the respective angular velocities of the pallet and the escape-wheel after impact, produces

$$\varepsilon = - \frac{(\dot{\psi}_f D_1 - \dot{\varphi}_f A_1)}{(\dot{\psi}_i D_1 - \dot{\varphi}_i A_1)} \qquad \text{(F19)}$$

Simultaneous solution of equations (F13) and (F19) furnishes the desired angular velocities after impact.

Thus,

$$\dot{\psi}_f = \frac{\dot{\varphi}_f A_1 - \varepsilon(\dot{\psi}_i D_1 - \dot{\varphi}_i A_1)}{D_1} \qquad \text{(F20)}$$

and

$$\dot{\varphi}_f = \frac{I_p F_2 \dot{\psi}_i + I_s E_2 \dot{\varphi}_i + \frac{I_p F_2 \varepsilon}{D_1}(\dot{\psi}_i D_1 - \dot{\varphi}_i A_1)}{\frac{I_p F_2 A_1}{D_1} + I_s E_2} \qquad \text{(F21)}$$

GENERAL EXPRESSIONS FOR THE NORMAL VELOCITIES AT THE IMPACT POINTS

The normal velocities at the impact points of the pallet and the escape-wheel are also used in the logic of the computer program. If $\dot{\varphi}$ and $\dot{\psi}$ represent the angular velocities of the escape-wheel and the pallet just before or after impact, expressions are derived for these velocities using (F1), (F2), (C5), and (C6):

For the pallet

$$V_p = \dot{\psi} c \cos(\varphi - \alpha - \psi) \qquad \text{(F22)}$$

For the escape wheel

$$V_s = \dot{\varphi}(b\cos\alpha + g) \qquad \text{(F23)}$$

(Note the simplification of the notation.)

APPENDIX G

COMPUTER PROGRAM

```
      PROGRAM ESCMT(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION AUX(8,2),PRMT(5),PHI(2),DPHI(2)
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      COMMON/ZETA/PSI,TIME,G,DPSI,DPSIP
      REAL IP,IS,LAMBDA,K
      EXTERNAL FCT,OUTP
C
C   READ IN AND WRITE DATA
C
      READ(5,1)A,B,C,R,ALPHA
    1 FORMAT(5F10.5)
      WRITE(6,2)A,B,C,R,ALPHA
    2 FORMAT(*1*,5X,*A=*,F13.5,5X,*B=*,F13.5,5X,*C=*,F13.5,5X,*R=*
     1F13.5,5X,*ALPHA=*,F9.4//)
      READ(5,3)TORK,COFR,IP,IS
    3 FORMAT(4E15.5)
      WRITE(6,4)TORK,COFR,IP,IS
    4 FORMAT(*0*,5X,*TORQUE=*,E15.5,5X,*COFR=*,E15.5,5X,*IPAL=*,E15.5,
     15X,*ISTAR=*,E15.5//)
      READ(5,5)EREST,LAMBDA,DELTA
    5 FORMAT(3F10.5)
      WRITE(6,6)EREST,LAMBDA,DELTA
    6 FORMAT(*0*,5X,*EREST=*,F5.2,3X,*LAMBDA=*,F8.3,3X,*DELTA=*,F8.3///)
      PI=3.14159
      Z=PI/180.
      ALPHR=ALPHA*Z
      PHID=135.
      TIME=0.
      PHITOT = 0.
      PHIPR = PHID
C
C   DATA FOR RUNGE KUTTA
C
      PRMT(2)=0.1
      PRMT(3)=0.0001
      PRMT(4)=0.001
      NDIM=2
      PHI(1)=PHID*Z
      PHI(2)=0.
   99 PRMT(1)=TIME
      DPHI(2)=0.5
      DPHI(1)=0.5
      IF(PHITOT .GT. 315.)GO TO 9999
      WRITE(6,7)
    7 FORMAT(*0*,5X,*COUPLED MOTION*)
C
C   COUPLED MOTION
C
  100 CALL RKGS(PRMT,PHI,DPHI,NDIM,IHLF,FCT,OUTP,AUX)
C
C   TEST FOR TOP OR BOTTOM ACTION
C
```

```
      IF(G.LT.0.)GO TO 200
   55 PHID=PHI(1)/Z

      IF(PHID.LE.150.)GO TO 150
      GO TO 151
  150 PHI(1)=PHI(1)+DELTA*Z
      PHIPR = PHI(1)/Z
   60 PSI=PSI+2.*PI-LAMBDA*Z
      GO TO 200
  151 PHI(1)=PHI(1)-DELTA*Z*2.
      PHIPR = PHI(1)/Z
      PSI=PSI-2.*PI+LAMBDA*Z
   65 C
      C  FREE MOTION
      C
  200 CALL FREE(TIME,PHI(1),PHI(2),PSI,DPSI)
      C
   70 C
      C
      PHID=PHI(1)/Z
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
   75 1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 204
      G=GTWO
   80 GO TO 205
  204 G=GONE
  205 PHID=PHI(1)/Z
      GP = C*COS(PHI(1) - ALPHR - PSI) - B*COS(ALPHR) - A*COS(PHI(1)
     1- ALPHR)
      IF(GP .LT. 0.)GO TO 250
   85 IF(PHID.LE.150.)GO TO 210
      GO TO 215
  210 PHI(1) = PHI(1) + DELTA*Z
      PHIPR = PHI(1)/Z
      PSI = PSI + 2.*PI - LAMBDA*Z
   90 GO TO 200
  215 PHI(1) = PHI(1) - DELTA*Z*2.
      PHIPR = PHI(1)/Z
      PSI = PSI - 2.*PI + LAMBDA*Z
   95 GO TO 200
  250 IF(PHID.LE.150.0)GO TO 9
      DPSIP=DPSI
      C
      C  COMPUTATION OF VELOCITIES VP AND VS FOR BOTTOM FREE MOTION TESTS
  100 C
      AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
  105
 9002 FORMAT(*0VP=*,F8.3,3X,*VS=*,F8.3)
```

```
      C
      C  BOTTOM FREE MOTION TESTS
      C
  110 IF(PHI(2).GE.0..AND.DPSI.GE.0.)GO TO 300
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 300
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.GE.0..AND.ABS(VP).GT.ABS(VS))GO TO 300
  115 IF(PHI(2).LE.0..AND.DPSI.GE.0..AND.ABS(VP).LT.ABS(VS))GO TO 200
      IF(PHI(2).LE.0..AND.DPSI.GE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.LE.0.)GO TO 200
      C
      C  COMPUTATION OF VELOCITIES VP AND VS FOR TOP FREE MOTION TESTS
  120 C
    9 AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
  125 WRITE(6,9002)VP,VS
      C
      C  TOP FREE MOTION TESTS
      C
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
  130 IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).LT.ABS(VS))GO TO 300
      IF(PHI(2).LE.0..AND.DPSI.GE.0.)GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0.)GO TO 300
      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 200
  135 IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 300
      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      C
      C  IMPACT
      C
  140 300 CALL IMPACT(PHI(1),PHI(2),PSI,DPSI)
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
  145 GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 310
      G=GTWO
      GO TO 311
  310 G=GONE
  311 DPSIP=DPSI
  150 IF(TIME.GT.0.1)GO TO 9999
      C
      C  TEST FOR BOTTOM ACTION
      C
  155 PHID=PHI(1)/Z
      IF(PHID.LE.150.0)GO TO 12
      C
      C  COMPUTATION OF VELOCITIES VP AND VS FOR BOTTOM IMPACT TESTS
      C
```

```
      AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
      IF(ABS(ABS(VP)-ABS(VS)).LT. 2.0)GO TO 99
C
C  BOTTOM IMPACT TESTS
C
      IF(PHI(2).GE.0..AND.DPSI.GE.0.)GO TO 99
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 99

      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99

      IF(PHI(2).LE.0..AND.DPSI.GT.0..AND.ABS(VP).LT.ABS(VS))GO TO 200
      IF(PHI(2).LE.0..AND.DPSI.GT.0..AND.ABS(VP).GT.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.GT.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.LE.0.)GO TO 200
C
C  COMPUTATION OF VELOCITIES VP AND VS FOR TOP IMPACT TESTS
C
   12 AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
      IF(ABS(ABS(VP)-ABS(VS)).LT. 2.0)GO TO 99
C
C  TOP IMPACT TESTS
C
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).LT.ABS(VS))GO TO 99
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.GE.0.)GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0.)GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 99

      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 200

      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
 9999 STOP
      END
```

```
      SUBROUTINE FCT(T,PHI,DPHI)
      REAL IP,IS,LAMBDA,K
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      DIMENSION PHI(2),DPHI(2),PRMT(5)
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+R**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 10
      G=GTWO
      GO TO 11
   10 G=GONE
   11 P=B*SIN(PHI(1))+G*SIN(PHI(1)-ALPHR)+R*COS(PHI(1)-ALPHR)
      Q=B*COS(PHI(1))+G*COS(PHI(1)-ALPHR)-R*SIN(PHI(1)-ALPHR)
      S=G+B*COS(ALPHR)+A*COS(PHI(1)-ALPHR)
      GDOT=PHI(2)*A*P/S
      PSI=ASIN(P/C)
      IF(PSI.LT.0.)GO TO 12
      GO TO 13
   12 PSI=2.*PI-ABS(PSI)
   13 AONE=B*COS(ALPHR)+G
      BONE=B*SIN(ALPHR)
      CONE=R+C*SIN(PHI(1)-ALPHR-PSI)
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      IF(GDOT.EQ.0.)GO TO 20
      GO TO 30
   20 EONE=DONE
      FONE=AONE
      GO TO 40
   30 EONE=DONE-COFR*CONE*GDOT/ABS(GDOT)
      FONE=AONE+COFR*BONE*GDOT/ABS(GDOT)
   40 CONTINUE
      U=(Q+SIN(PHI(1)-ALPHR)*P*A/S)/(C*COS(PSI))
      V=(Q+A*P*SIN(PHI(1)-ALPHR)/S)**2*TAN(PSI)/(C**2*
     1(COS(PSI))**2)+(1./(C*COS(PSI)))*(2.*A*P*COS(PHI(1)-ALPHR)/S
     2-P*2.*A**2*P*(SIN(PHI(1)-ALPHR))**2/S**2+A*Q*SIN(PHI(1)
     3-ALPHR)/S-A**2*P**2*SIN(PHI(1)-ALPHR)/S**3)
      W=(IP*V/EONE)/(IP*U/EONE+IS/FONE)
      Y=(TORK/FONE)/(IP*U/EONE+IS/FONE)
      DPHI(1)=PHI(2)
      DPHI(2)=Y-W*PHI(2)**2
      RETURN
      END
```

```
      SUBROUTINE OUTP(T,PHI,DPHI,IHLF,NDIM,PRMT)
      REAL IP,IS,LAMBDA,K
      DIMENSION PHI(2),DPHI(2),PRMT(5)
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      COMMON/ZETA/PSI,TIME,G,DPSI,DPSIP
      Z=180./PI
      IF(T.EQ.0.)DPSIP=0.
      PHID=PHI(1)*Z
C
C  COMPUTE PSID
C
      DELPHI = PHID - PHIPR
      PHITOT = PHITOT + DELPHI
      PHIPR = PHID
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 1
      G=GTWO
      GO TO 2
    1 G=GONE
    2 P=B*SIN(PHI(1))+G*SIN(PHI(1)-ALPHR)+R*COS(PHI(1)-ALPHR)

      PSI=ASIN(P/C)
      IF(PSI.LT.0.)PSI=2.*PI-ABS(PSI)
      PSID=PSI*Z
C
C  COMPUTE DPSI
C
      S=G+B*COS(ALPHR)+A*COS(PHI(1)-ALPHR)
      GDOT=PHI(2)*A*P/S
      Q=B*COS(PHI(1))+G*COS(PHI(1)-ALPHR)-R*SIN(PHI(1)-ALPHR)
      DPSI=(PHI(2)*Q+GDOT*SIN(PHI(1)-ALPHR))/(C*COS(PSI))
C
C  TEST FOR CONTINATION OF COUPLED MOTION
C
      IF(T.EQ.TIME)GO TO 4
      IF(T.EQ. 0.)GO TO 4
      IF(.NOT.(G.LT. 0. .AND. ((ABS(DPSI).GT. ABS(DPSIP) .AND. PHI(2)
     1.GT. 0.) .OR. (ABS(DPSI).LT.ABS(DPSIP) .AND. PHI(2) .LT. 0.)).AND.
     2T.NE.0.))PRMT(5) = 1.
      IF(ABS(DPSI) .LT. 1.)PRMT(5) = 0.
C
C  WRITE OUTPUT
C
    4 WRITE(6,3)T,PHID,PHI(2),G,GDOT,PSID,DPSI,PHITOT
    3 FORMAT(' ',5X,'T=',F8.5,3X,'PHI=',F8.3,3X,'PHIDOT=',F8.3,3X,
     1'G=',F9.4,3X,'GDOT=',F8.3,3X,'PSID=',F8.3,3X,'PSIDOT=',F8.3,
     213X,'PHITOT =',F8.3)
    5 DPSIP=DPSI
      TIME=T
```

```
      RETURN
   55 END
```

```
      SUBROUTINE IMPACT(PHI,DPHI,PSI,DPSI)
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      REAL IP,IS,LAMBDA,K
      H=2.*(B*COS(ALPHR)+A*COS(PHI-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B*COS(PHI)-
     12.*A*R*SIN(PHI-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 1
      G=GTWO
      GO TO 2
    1 G=GONE
    2 AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI-ALPHR-PSI)

      DPHIIN=DPHI
      DPSIIN=DPSI
      DPHIF=(IP*AONE*DPSIIN+IS*DONE*DPHIIN+IP*AONE*EREST/DONE*(DPSIIN
     1*DONE-DPHIIN*AONE))/(IP*AONE**2/DONE+IS*DONE)
      DPSIF=(DPHIF*AONE-EREST*(DPSIIN*DONE-DPHIIN*AONE))/DONE
      PHID=PHI*180./PI
      PSID=PSI*180./PI
      WRITE(6,3)
    3 FORMAT(*0*,5X,*IMPACT*)
      WRITE(6,5)PHID,DPHIF,PSID,DPSIF,PHITOT
    5 FORMAT(*0*,19X,*PHI=*,F8.3,3X,*DPHIF=*,F8.3,3X,*PSI=*,F8.3,3X,
     1*DPSIF=*,F8.3,3X,*PHITOT=*,F8.3)
      DPHI=DPHIF
      DPSI=DPSIF
    6 RETURN
      END
```

```
      SUBROUTINE FREE(TIME,PHI,DPHI,PSI,DPSI)
      REAL IP,IS,LAMBDA,K
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      T=TIME
      Z=PI/180.
C
C  RECORD INITIAL VALUES
C
      PHIIN=PHI
      DPHIIN=DPHI
      PSIIN=PSI
      DPSIIN = DPSI
      WRITE(6,5)
    5 FORMAT(*0*,5X,*FREE MOTION*)
C
C  STARWHEEL MOTION
C
    1 PHI=TORK/(2.*IS)*(T-TIME)*(T-TIME)+DPHIIN*(T-TIME)+PHIIN
      PHID=PHI/Z
      DELPHI=PHID-PHIPR
      PHITOT = PHITOT + DELPHI
      PHIPR = PHID
      DPHI=TORK/IS*(T-TIME)+DPHIIN
C
C  PALLET MOTION
C
      PSI = DPSIIN*(T-TIME) + PSIIN
      DPSI = DPSIIN
      PSID=PSI/Z
C
C  OUTPUT
C
      WRITE(6,2)T,PHID,DPHI,PSID,DPSI,PHITOT
    2 FORMAT(* *,5X,*T=*,F8.5,3X,*PHI=*,F8.3,3X,*PHDOT=*,F8.3,3X,
     1*PSI=*,F8.3,3X,*PSIDOT=*,F8.3,3X,*PHITOT =*,F8.3)
    9 IF(T.EQ.TIME)GO TO 3
C
C  CHECK FOR CONTINUED FREE MOTION
C
      F=A*SIN(PHI-ALPHR)-B*SIN(ALPHR)-C*SIN(PHI-ALPHR-PSI)-R
      GP=C*COS(PHI-ALPHR-PSI)-B*COS(ALPHR)-A*COS(PHI-ALPHR)
      IF(F.LE.0.)GO TO 4
C
C  CHECK FOR TOP OR BOTTOM ACTION
C
      IF(GP.LE.0.)GO TO 3
      PHID=PHI/Z
      IF(PHID.LE.150.)GO TO 6
      GO TO 7
    6 PHI=PHI+DELTA*Z
      PHIPR = PHI/Z
      PSI=PSI+2.*PI-LAMBDA*Z
```

```
      PSIIN = PSIIN + 2.*PI-LAMBDA*Z
      PHIIN = PHIIN + DELTA*Z
      GO TO 3
    7 PHI=PHI-DELTA*Z*2.
      PHIPR = PHI/Z
      PSI=PSI-2.*PI+LAMBDA*Z
      PHIIN = PHIIN - DELTA*Z*2.
      PSIIN = PSIIN -  2.*PI+LAMBDA*Z
C
C  INCREMENT TIME
C
    3 T=T+.00001
C
C  CONTINUE FREE MOTION
C
      GO TO 1
C
C  END OF FRFE MOTION
C
    4 TIME=T
      RETURN
      END
```

APPENDIX H

SOME GEOMETRIC RELATIONSHIP

DETERMINATION OF g_{MAX}

Figure H-1 shows the geometrical relationship between the pallet pin of radius r and the right hand escape-wheel tooth when the quantity g (equation (A12) in appendix A) reaches its maximum possible absolute value. The following relationship holds between the angles α and β:

$$\alpha = \beta - \frac{\delta}{2} \tag{H1}$$

where

$$\delta = \frac{360}{N} \tag{H2}$$

and N stands for the number of teeth on the escape-wheel.

The distance $\overline{ST}$ of the triangle OST is determined with the help of the sine law:

$$\overline{ST} = b \frac{\sin(\delta/2)}{\sin(\pi - \beta)} \tag{H3}$$

where b represents the escape-wheel radius.

Finally, g_{MAX} is obtained from:

$$g_{MAX} = \overline{ST} - \frac{r}{\tan\beta} \tag{H4}$$

To use g_{MAX} in connection with expressions derived in appendix A, it must be furnished with a minus sign to conform to the origin of the $\bar{n}_t - \bar{n}_n$ system.

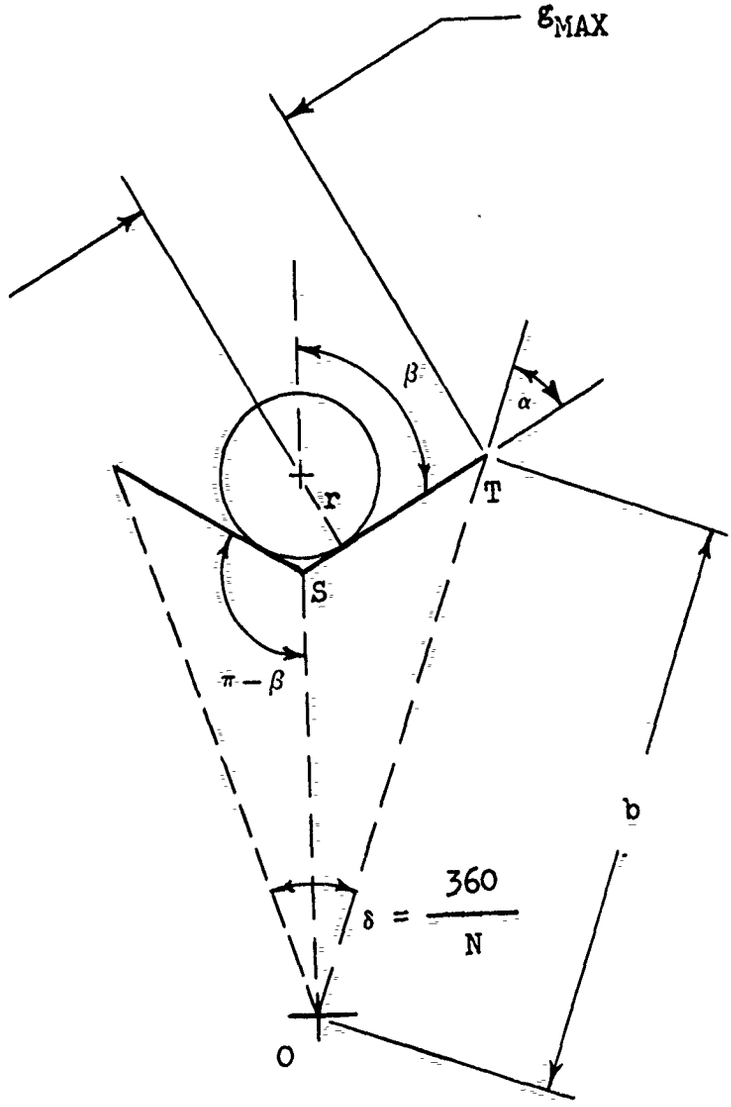


Figure H1. Configuration for g_{MAX}

DETERMINATION OF ESCAPE-WHEEL ANGLE φ_M CORRESPONDING TO $g = g_{MAX}$

The angle $\varphi = \varphi_M$, which corresponds to the maximum possible value of $g = g_{MAX}$, is obtained with the help of equation (A11) of appendix A:

$$g_{MAX}^2 + g_{MAX}[2b\cos\alpha + 2a\cos(\varphi_M - \alpha)] + [a^2 + b^2 + r^2 - c^2 + 2br\sin\alpha + 2ab\cos\varphi_M - 2ar\sin(\varphi_M - \alpha)] = 0 \qquad (H5)$$

After the expansion of the trigonometric terms $\cos(\varphi_M - \alpha)$ and $\sin(\varphi_M - \alpha)$, the following expression results:

$$L\sin\varphi_M + M\cos\varphi_M + N = 0 \qquad (H6)$$

where

$$L = 2a(g_{MAX}\sin\alpha - r\cos\alpha)$$

$$M = 2a(g_{MAX}\cos\alpha + b + r\sin\alpha)$$

$$N = g_{MAX}^2 + a^2 + b^2 + r^2 - c^2 + 2b(g_{MAX}\cos\alpha + r\sin\alpha)$$

Equation (H5) may now be rewritten with the help of the following trigonometric identities:

$$\sin\varphi_M = \frac{2\tan(\frac{\varphi_M}{2})}{1 + \tan^2(\frac{\varphi_M}{2})} \qquad (H7)$$

$$\cos\varphi_M = \frac{1 - \tan^2(\frac{\varphi_M}{2})}{1 + \tan^2(\frac{\varphi_M}{2})} \qquad (H8)$$

This leads to:

$$(N - M)\tan^2\left(\frac{\varphi_M}{2}\right) + 2L\tan\left(\frac{\varphi_M}{2}\right) + (M + N) = 0 \qquad \text{(H9)}$$

This expression may now be solved for the angle φ_M using the solution for a quadratic equation. Accordingly,

$$\varphi_M = 2\tan^{-1}\left[\frac{-L \pm \sqrt{L^2 - N^2 + M^2}}{N - M}\right] \qquad \text{(H10)}$$

The two solutions correspond to top and bottom action.

DETERMINATION OF ESCAPE-WHEEL ANGLE φ CORRESPONDING TO $g = 0$

The angle $\varphi = \varphi_o$, which is associated with the instant when the pallet pin leaves the escape-wheel tooth during coupled motion, is obtained from equation (A11) with $g = 0$.

An expression similar to equation (H6) results:

$$L_o \sin\varphi_o + M_o \cos\varphi_o + N_o = 0 \qquad \text{(H11)}$$

where

$$L_o = -2a\cos\alpha$$

$$M_o = 2a(b + r\sin\alpha)$$

$$N_o = a^2 + b^2 + r^2 - c^2 + 2br\sin\alpha$$

Equation (H11) is solved in the same manner as equation (H6).

This results in:

$$\varphi_o = 2\tan^{-1}\left[\frac{-L_o \pm \sqrt{L_o^2 - N_o^2 + M_o^2}}{N_o - M_o}\right] \qquad \text{(H12)}$$

Again, top and bottom action results are provided.

DISENGAGEMENT DISTANCE BETWEEN PALLET AND ESCAPE-WHEEL PIVOTS

Figure H-2 shows the disengagement configuration of the symmetrical pin pallet runaway escapement. The pallet angle ψ equals $\frac{\lambda}{2}$ when both pallet pins together are least advanced with respect to the escape-wheel. The center distance a is such that the escape-wheel radius b and the pallet pin radius r are collinear.

The disengagement center distance a_{dis} is determined with the help of the cosine law:

$$(b + r)^2 = a_{dis}^2 + c^2 - 2a_{dis}(c)\cos\left(\frac{\lambda}{2}\right) \qquad \text{(H13)}$$

From the solution of the quadratic equation, one finds:

$$a_{dis} = (c)\cos\left(\frac{\lambda}{2}\right) + \sqrt{\left[(c)\cos\left(\frac{\lambda}{2}\right)\right]^2 - [c^2 - (b + r)^2]} \qquad \text{(H14)}$$

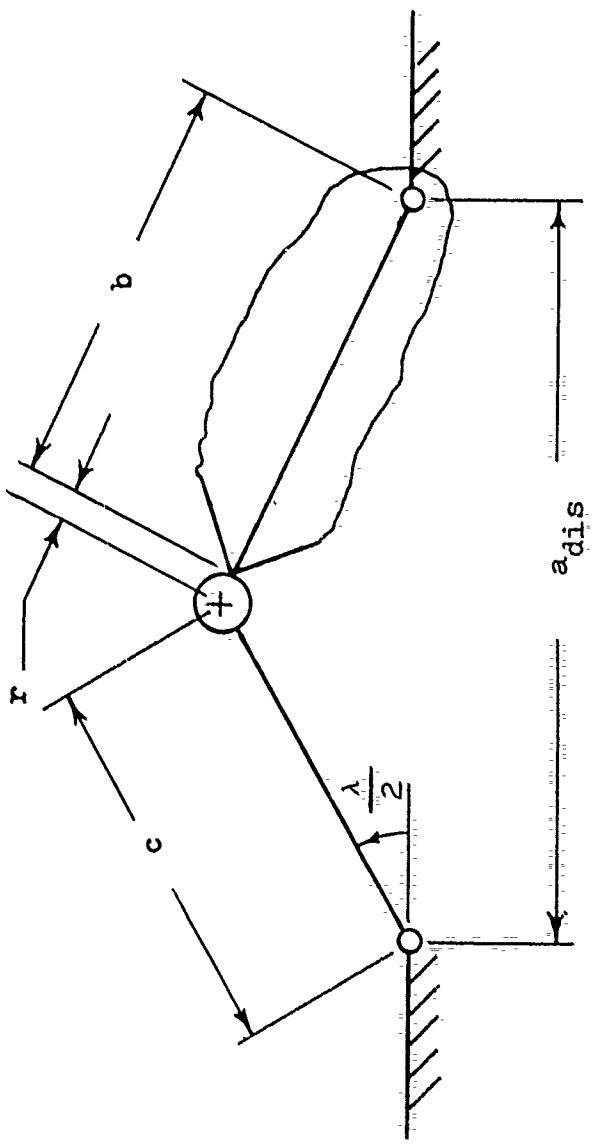


Figure H2. Disengagement condition

APPENDIX I

COMPUTER OUTPUT FOR STANDARD CONFIGURATION WITH $\mu = .3$ AND $\varepsilon = .25$

A= .19310 B= .15838 C= .09683 R= .01365 ALPHA= 40.0000

TORQUE= .17700E-01 COFR= .30000E+00 IPAL= .91000E-07 ISTAR= .17000E-07

Appendix I
Std.Config.
μ = .3, ε = .25

EREST= .25 LAMBDA= 109.337 DELTA= 40.000

Cycle No. 1

COUPLED MOTION

T= 0.00000	PHI= 135.000	PHIDOT= 0.000	G= -.0457	GDOT= 0.000	PSI= 42.412	PSIDOT= 0.000	PHITOT = -.000				
T= .00000	PHI= 135.000	PHIDOT= .084	G= -.0457	GDOT= .018	PSI= 42.412	PSIDOT= .108	PHITOT = .000				
T= .00000	PHI= 135.000	PHIDOT= .151	G= -.0457	GDOT= .032	PSI= 42.412	PSIDOT= .195	PHITOT = .000				
T= .00000	PHI= 135.000	PHIDOT= .210	G= -.0457	GDOT= .047	PSI= 42.412	PSIDOT= .281	PHITOT = .000				
T= .00001	PHI= 135.000	PHIDOT= .286	G= -.0457	GDOT= .061	PSI= 42.412	PSIDOT= .368	PHITOT = .000				
T= .00001	PHI= 135.000	PHIDOT= .421	G= -.0457	GDOT= .090	PSI= 42.412	PSIDOT= .542	PHITOT = .000				
T= .00001	PHI= 135.000	PHIDOT= .554	G= -.0457	GDOT= .119	PSI= 42.412	PSIDOT= .716	PHITOT = .000				
T= .00002	PHI= 135.000	PHIDOT= .827	G= -.0457	GDOT= .177	PSI= 42.413	PSIDOT= 1.063	PHITOT = .000				
T= .00002	PHI= 135.001	PHIDOT= 1.097	G= -.0457	GDOT= .235	PSI= 42.413	PSIDOT= 1.410	PHITOT = .001				
T= .00004	PHI= 135.002	PHIDOT= 1.637	G= -.0457	GDOT= .351	PSI= 42.414	PSIDOT= 2.105	PHITOT = .002				
T= .00005	PHI= 135.003	PHIDOT= 2.177	G= -.0457	GDOT= .467	PSI= 42.416	PSIDOT= 2.800	PHITOT = .003				
T= .00007	PHI= 135.007	PHIDOT= 3.256	G= -.0456	GDOT= .698	PSI= 42.421	PSIDOT= 4.189	PHITOT = .007				
T= .00010	PHI= 135.012	PHIDOT= 4.336	G= -.0456	GDOT= .930	PSI= 42.428	PSIDOT= 5.579	PHITOT = .012				
T= .00015	PHI= 135.028	PHIDOT= 6.490	G= -.0456	GDOT= 1.392	PSI= 42.448	PSIDOT= 8.357	PHITOT = .028				
T= .00020	PHI= 135.050	PHIDOT= 8.639	G= -.0455	GDOT= 1.854	PSI= 42.476	PSIDOT= 11.134	PHITOT = .050				
T= .00030	PHI= 135.111	PHIDOT= 12.913	G= -.0453	GDOT= 2.774	PSI= 42.556	PSIDOT= 16.686	PHITOT = .111				
T= .00040	PHI= 135.198	PHIDOT= 17.142	G= -.0449	GDOT= 3.688	PSI= 42.667	PSIDOT= 22.232	PHITOT = .198				
T= .00050	PHI= 135.308	PHIDOT= 21.311	G= -.0445	GDOT= 4.594	PSI= 42.811	PSIDOT= 27.771	PHITOT = .308				
T= .00060	PHI= 135.442	PHIDOT= 25.413	G= -.0440	GDOT= 5.491	PSI= 42.984	PSIDOT= 33.300	PHITOT = .442				
T= .00070	PHI= 135.599	PHIDOT= 29.437	G= -.0434	GDOT= 6.376	PSI= 43.192	PSIDOT= 38.819	PHITOT = .599				
T= .00080	PHI= 135.779	PHIDOT= 33.366	G= -.0427	GDOT= 7.250	PSI= 43.430	PSIDOT= 44.326	PHITOT = .779				
T= .00090	PHI= 135.981	PHIDOT= 37.189	G= -.0420	GDOT= 8.109	PSI= 43.700	PSIDOT= 49.819	PHITOT = .981				
T= .00100	PHI= 136.205	PHIDOT= 40.911	G= -.0411	GDOT= 8.954	PSI= 44.001	PSIDOT= 55.298	PHITOT = 1.205				
T= .00110	PHI= 136.449	PHIDOT= 44.523	G= -.0402	GDOT= 9.784	PSI= 44.334	PSIDOT= 60.762	PHITOT = 1.449				
T= .00120	PHI= 136.715	PHIDOT= 48.018	G= -.0392	GDOT= 10.597	PSI= 44.697	PSIDOT= 66.211	PHITOT = 1.715				
T= .00130	PHI= 136.999	PHIDOT= 51.397	G= -.0381	GDOT= 11.394	PSI= 45.092	PSIDOT= 71.642	PHITOT = 1.999				
T= .00140	PHI= 137.303	PHIDOT= 54.659	G= -.0369	GDOT= 12.173	PSI= 45.519	PSIDOT= 77.058	PHITOT = 2.303				
T= .00150	PHI= 137.626	PHIDOT= 57.804	G= -.0356	GDOT= 12.935	PSI= 45.975	PSIDOT= 82.457	PHITOT = 2.626				
T= .00160	PHI= 137.966	PHIDOT= 60.833	G= -.0343	GDOT= 13.680	PSI= 46.463	PSIDOT= 87.840	PHITOT = 2.966				
T= .00170	PHI= 138.322	PHIDOT= 63.750	G= -.0329	GDOT= 14.408	PSI= 46.982	PSIDOT= 93.207	PHITOT = 3.322				
T= .00180	PHI= 138.696	PHIDOT= 66.558	G= -.0314	GDOT= 15.118	PSI= 47.531	PSIDOT= 98.559	PHITOT = 3.696				
T= .00190	PHI= 139.085	PHIDOT= 69.261	G= -.0299	GDOT= 15.812	PSI= 48.111	PSIDOT= 103.896	PHITOT = 4.085				
T= .00200	PHI= 139.489	PHIDOT= 71.864	G= -.0282	GDOT= 16.489	PSI= 48.722	PSIDOT= 109.220	PHITOT = 4.489				
T= .00210	PHI= 139.908	PHIDOT= 74.372	G= -.0266	GDOT= 17.150	PSI= 49.361	PSIDOT= 114.532	PHITOT = 4.908				
T= .00220	PHI= 140.341	PHIDOT= 76.796	G= -.0248	GDOT= 17.794	PSI= 50.034	PSIDOT= 119.832	PHITOT = 5.341				
T= .00230	PHI= 140.788	PHIDOT= 79.125	G= -.0230	GDOT= 18.424	PSI= 50.736	PSIDOT= 125.123	PHITOT = 5.788				
T= .00240	PHI= 141.248	PHIDOT= 81.381	G= -.0211	GDOT= 19.038	PSI= 51.468	PSIDOT= 130.405	PHITOT = 6.248				
T= .00250	PHI= 141.721	PHIDOT= 83.564	G= -.0192	GDOT= 19.637	PSI= 52.230	PSIDOT= 135.680	PHITOT = 6.721				
T= .00260	PHI= 142.205	PHIDOT= 85.681	G= -.0172	GDOT= 20.221	PSI= 53.023	PSIDOT= 140.950	PHITOT = 7.205				
T= .00270	PHI= 142.702	PHIDOT= 87.744	G= -.0152	GDOT= 20.792	PSI= 53.845	PSIDOT= 146.216	PHITOT = 7.702				
T= .00280	PHI= 143.211	PHIDOT= 89.741	G= -.0131	GDOT= 21.349	PSI= 54.698	PSIDOT= 151.480	PHITOT = 8.211				
T= .00290	PHI= 143.731	PHIDOT= 91.693	G= -.0109	GDOT= 21.892	PSI= 55.581	PSIDOT= 156.743	PHITOT = 8.731				
T= .00300	P_{HI}= 144.261	P_{HIDOT}= 93.598	G= -.0087	$GDOT$= 22.421	PS_{IO}= 56.494	PS_{IDOT}= 162.008	$P_{HI}T_{OT}$ = 9.261				
T= .00310	PHI= 144.803	$PHIDOT$= 95.467	G= -.0064	$GDOT$= 22.938	PSI= 57.438	$PSIDOT$= 167.275	$PHITOT$ = 9.803				
T= .00320	PHI= 145.355	PHIDOT= 97.299	G= -.0041	GDOT= 23.441	PSI= 58.411	PSIDOT= 172.547	PHITOT = 10.355				
T= .00330	PHI= 145.918	PHIDOT= 99.090	G= -.0017	GDOT= 23.931	PSI= 59.415	PSIDOT= 177.825	PHITOT = 10.918				

```
        T=  .00340   PHI= 186.491   PHIDOT= 100.859   G=    .0007   GDOT=  24.408   PSID=  60.449   PSIDOT= 183.111   PHITOT =  11.491

        FREE MOTION
        T=  .00340   PHI= 186.491   PHIDOT= 100.659   PSI= 311.112   PSIDOT= 183.111   PHITOT =  11.491
        T=  .00341   PHI= 186.551   PHIDOT= 111.271   PSI= 311.217   PSIDOT= 183.111   PHITOT =  11.551
        T=  .00342   PHI= 186.618   PHIDOT= 121.883   PSI= 311.322   PSIDOT= 183.111   PHITOT =  11.618
        T=  .00343   PHI= 186.691   PHIDOT= 132.095   PSI= 311.427   PSIDOT= 183.111   PHITOT =  11.691
        T=  .00344   PHI= 186.770   PHIDOT= 142.506   PSI= 311.532   PSIDOT= 183.111   PHITOT =  11.770
        T=  .00345   PHI= 186.854   PHIDOT= 152.918   PSI= 311.637   PSIDOT= 183.111   PHITOT =  11.854
        T=  .00346   PHI= 186.945   PHIDOT= 163.330   PSI= 311.742   PSIDOT= 183.111   PHITOT =  11.945
        T=  .00347   PHI= 187.041   PHIDOT= 173.742   PSI= 311.846   PSIDOT= 183.111   PHITOT =  12.041
        T=  .00348   PHI= 187.144   PHIDOT= 184.153   PSI= 311.951   PSIDOT= 183.111   PHITOT =  12.144
        T=  .00349   PHI= 187.252   PHIDOT= 194.565   PSI= 312.056   PSIDOT= 183.111   PHITOT =  12.252
        T=  .00350   PHI= 187.367   PHIDOT= 204.977   PSI= 312.161   PSIDOT= 183.111   PHITOT =  12.367
        T=  .00351   PHI= 187.487   PHIDOT= 215.389   PSI= 312.266   PSIDOT= 183.111   PHITOT =  12.487
        T=  .00352   PHI= 187.614   PHIDOT= 225.800   PSI= 312.371   PSIDOT= 183.111   PHITOT =  12.614
        T=  .00353   PHI= 187.746   PHIDOT= 236.212   PSI= 312.476   PSIDOT= 183.111   PHITOT =  12.746
        T=  .00354   PHI= 187.884   PHIDOT= 246.624   PSI= 312.581   PSIDOT= 183.111   PHITOT =  12.886
        T=  .00355   PHI= 188.029   PHIDOT= 257.036   PSI= 312.686   PSIDOT= 183.111   PHITOT =  13.029
        T=  .00356   PHI= 188.179   PHIDOT= 267.447   PSI= 312.791   PSIDOT= 183.111   PHITOT =  13.179

        T=  .00357   PHI= 188.335   PHIDOT= 277.859   PSI= 312.896   PSIDOT= 183.111   PHITOT =  13.335
        T=  .00358   PHI= 188.497   PHIDOT= 288.271   PSI= 313.001   PSIDOT= 183.111   PHITOT =  13.497
        T=  .00359   PHI= 188.665   PHIDOT= 298.683   PSI= 313.105   PSIDOT= 183.111   PHITOT =  13.665
        T=  .00360   PHI= 188.840   PHIDOT= 309.095   PSI= 313.210   PSIDOT= 183.111   PHITOT =  13.840
        T=  .00361   PHI= 189.020   PHIDOT= 319.506   PSI= 313.315   PSIDOT= 183.111   PHITOT =  14.020
        T=  .00362   PHI= 189.206   PHIDOT= 329.918   PSI= 313.420   PSIDOT= 183.111   PHITOT =  14.206
        T=  .00363   PHI= 189.398   PHIDOT= 340.330   PSI= 313.525   PSIDOT= 183.111   PHITOT =  14.398
        T=  .00364   PHI= 189.596   PHIDOT= 350.742   PSI= 313.630   PSIDOT= 183.111   PHITOT =  14.596
        T=  .00365   PHI= 189.800   PHIDOT= 361.153   PSI= 313.735   PSIDOT= 183.111   PHITOT =  14.800
        T=  .00366   PHI= 190.010   PHIDOT= 371.565   PSI= 313.840   PSIDOT= 183.111   PHITOT =  15.010
        T=  .00367   PHI= 190.225   PHIDOT= 381.977   PSI= 313.945   PSIDOT= 183.111   PHITOT =  15.225
        T=  .00368   PHI= 190.447   PHIDOT= 392.389   PSI= 314.050   PSIDOT= 183.111   PHITOT =  15.447
        T=  .00369   PHI= 190.675   PHIDOT= 402.800   PSI= 314.155   PSIDOT= 183.111   PHITOT =  15.675
        T=  .00370   PHI= 190.909   PHIDOT= 413.212   PSI= 314.260   PSIDOT= 183.111   PHITOT =  15.909
        T=  .00371   PHI= 191.149   PHIDOT= 423.624   PSI= 314.364   PSIDOT= 183.111   PHITOT =  16.149
        T=  .00372   PHI= 191.394   PHIDOT= 434.036   PSI= 314.469   PSIDOT= 183.111   PHITOT =  16.394
        T=  .00373   PHI= 191.646   PHIDOT= 444.447   PSI= 314.574   PSIDOT= 183.111   PHITOT =  16.646
        T=  .00374   PHI= 191.904   PHIDOT= 454.859   PSI= 314.679   PSIDOT= 183.111   PHITOT =  16.904
        T=  .00375   PHI= 192.167   PHIDOT= 465.271   PSI= 314.784   PSIDOT= 183.111   PHITOT =  17.167
        T=  .00376   PHI= 192.437   PHIDOT= 475.683   PSI= 314.889   PSIDOT= 183.111   PHITOT =  17.437
        T=  .00377   PHI= 192.712   PHIDOT= 486.095   PSI= 314.994   PSIDOT= 183.111   PHITOT =  17.712
        T=  .00378   PHI= 192.994   PHIDOT= 496.506   PSI= 315.099   PSIDOT= 183.111   PHITOT =  17.994
        T=  .00379   PHI= 193.281   PHIDOT= 506.918   PSI= 315.204   PSIDOT= 183.111   PHITOT =  18.281
        T=  .00380   PHI= 193.575   PHIDOT= 517.330   PSI= 315.309   PSIDOT= 183.111   PHITOT =  18.575
        T=  .00381   PHI= 193.874   PHIDOT= 527.742   PSI= 315.414   PSIDOT= 183.111   PHITOT =  18.874
        T=  .00382   PHI= 194.179   PHIDOT= 538.153   PSI= 315.518   PSIDOT= 183.111   PHITOT =  19.179
  VP= -16.798   VS=  44.239

        IMPACT

                     PHI= 194.179   DPHIF=-214.794   PSI= 315.518   DPSIF=  26.138   PHITOT=  19.179
  VP=  -2.398   VS= -17.657

        FREE MOTION
        T=  .00382   PHI= 194.179   PHIDOT=-214.794   PSI= 315.518   PSIDOT=  26.138   PHITOT =  19.179
        T=  .00383   PHI= 194.059   PHIDOT=-204.382   PSI= 315.533   PSIDOT=  26.138   PHITOT =  19.059
  VP=  -2.400   VS= -16.740

        FREE MOTION
        T=  .00383   PHI= 194.059   PHIDOT=-204.382   PSI= 315.533   PSIDOT=  26.138   PHITOT =  19.059
        T=  .00384   PHI= 193.945   PHIDOT=-193.970   PSI= 315.548   PSIDOT=  26.138   PHITOT =  18.945
  VP=  -2.402   VS= -15.832

        FREE MOTION
        T=  .00384   PHI= 193.945   PHIDOT=-193.970   PSI= 315.548   PSIDOT=  26.138   PHITOT =  18.945
```

T= .00385	PHI= 193.837	PHIDOT=-183.559	PSI= 315.543	PSIDOT= 26.135	PHITOT = 18.837
T= .00386	PHI= 193.735	PHIDOT=-173.147	PSI= 315.578	PSIDOT= 26.135	PHITOT = 18.735
T= .00387	PHI= 193.639	PHIDOT=-162.735	PSI= 315.593	PSIDOT= 26.135	PHITOT = 18.639
T= .00388	PHI= 193.548	PHIDOT=-152.323	PSI= 315.606	PSIDOT= 26.135	PHITOT = 18.548
T= .00389	PHI= 193.464	PHIDOT=-141.912	PSI= 315.623	PSIDOT= 26.135	PHITOT = 18.464
T= .00390	PHI= 193.386	PHIDOT=-131.500	PSI= 315.638	PSIDOT= 26.135	PHITOT = 18.386
T= .00391	PHI= 193.313	PHIDOT=-121.088	PSI= 315.653	PSIDOT= 26.135	PHITOT = 18.313
T= .00392	PHI= 193.247	PHIDOT=-110.676	PSI= 315.668	PSIDOT= 26.135	PHITOT = 18.247
T= .00393	PHI= 193.187	PHIDOT=-100.265	PSI= 315.683	PSIDOT= 26.135	PHITOT = 18.187
T= .00394	PHI= 193.132	PHIDOT= -89.853	PSI= 315.698	PSIDOT= 26.135	PHITOT = 18.132
T= .00395	PHI= 193.084	PHIDOT= -79.441	PSI= 315.713	PSIDOT= 26.135	PHITOT = 18.084
T= .00396	PHI= 193.041	PHIDOT= -69.029	PSI= 315.728	PSIDOT= 26.135	PHITOT = 18.041
T= .00397	PHI= 193.004	PHIDOT= -58.617	PSI= 315.743	PSIDOT= 26.135	PHITOT = 18.004
T= .00398	PHI= 192.974	PHIDOT= -48.206	PSI= 315.758	PSIDOT= 26.135	PHITOT = 17.974
T= .00399	PHI= 192.949	PHIDOT= -37.794	PSI= 315.773	PSIDOT= 26.135	PHITOT = 17.949
T= .00400	PHI= 192.931	PHIDOT= -27.382	PSI= 315.788	PSIDOT= 26.135	PHITOT = 17.931
T= .00401	PHI= 192.918	PHIDOT= -16.970	PSI= 315.803	PSIDOT= 26.135	PHITOT = 17.918
T= .00402	PHI= 192.911	PHIDOT= -6.559	PSI= 315.818	PSIDOT= 26.135	PHITOT = 17.911
T= .00403	PHI= 192.910	PHIDOT= 3.853	PSI= 315.833	PSIDOT= 26.135	PHITOT = 17.910
T= .00404	PHI= 192.916	PHIDOT= 14.265	PSI= 315.848	PSIDOT= 26.135	PHITOT = 17.916
T= .00405	PHI= 192.927	PHIDOT= 24.677	PSI= 315.863	PSIDOT= 26.135	PHITOT = 17.927
T= .00406	PHI= 192.944	PHIDOT= 35.088	PSI= 315.878	PSIDOT= 26.135	PHITOT = 17.944
T= .00407	PHI= 192.967	PHIDOT= 45.500	PSI= 315.893	PSIDOT= 26.135	PHITOT = 17.967
T= .00408	PHI= 192.996	PHIDOT= 55.912	PSI= 315.908	PSIDOT= 26.135	PHITOT = 17.996
T= .00409	PHI= 193.031	PHIDOT= 66.324	PSI= 315.923	PSIDOT= 26.135	PHITOT = 18.031
T= .00410	PHI= 193.072	PHIDOT= 76.735	PSI= 315.938	PSIDOT= 26.135	PHITOT = 18.072
T= .00411	PHI= 193.119	PHIDOT= 87.147	PSI= 315.953	PSIDOT= 26.135	PHITOT = 18.119
T= .00412	PHI= 193.172	PHIDOT= 97.559	PSI= 315.968	PSIDOT= 26.135	PHITOT = 18.172
T= .00413	PHI= 193.231	PHIDOT= 107.971	PSI= 315.983	PSIDOT= 26.135	PHITOT = 18.231
T= .00414	PHI= 193.296	PHIDOT= 118.383	PSI= 315.998	PSIDOT= 26.135	PHITOT = 18.296
T= .00415	PHI= 193.366	PHIDOT= 128.794	PSI= 316.013	PSIDOT= 26.135	PHITOT = 18.366

VP= -2.416 VS= 10.328

IMPACT

PHI= 193.366 DPHIF= [illegible] PSI= 316.013 DPSIF= -8.136 PHITOT= 18.366

VP= .751 VS= -2.435

COUPLED MOTION

T= .00415	PHI= 193.366	PHIDOT= -32.363	G= -.0411	GDOT= -4.266	PSID= 316.007	PSIDOT= 26.343	PHITOT = 18.366
T= .00417	PHI= 193.328	PHIDOT= -22.673	G= -.0412	GDOT= -3.183	PSID= 316.046	PSIDOT= 19.642	PHITOT = 18.328
T= .00420	PHI= 193.301	PHIDOT= -14.955	G= -.0413	GDOT= -2.098	PSID= 316.063	PSIDOT= 12.942	PHITOT = 18.301
T= .00421	PHI= 193.292	PHIDOT= -11.083	G= -.0413	GDOT= -1.555	PSID= 316.071	PSIDOT= 9.592	PHITOT = 18.292
T= .00422	PHI= 193.286	PHIDOT= -7.213	G= -.0413	GDOT= -1.012	PSID= 316.077	PSIDOT= 6.242	PHITOT = 18.286
T= .00423	PHI= 193.283	PHIDOT= -5.281	G= -.0413	GDOT= -.741	PSID= 316.079	PSIDOT= 4.567	PHITOT = 18.283
T= .00424	PHI= 193.282	PHIDOT= -3.349	G= -.0413	GDOT= -.469	PSID= 316.080	PSIDOT= 2.892	PHITOT = 18.282
T= .00424	PHI= 193.281	PHIDOT= -2.374	G= -.0413	GDOT= -.333	PSID= 316.081	PSIDOT= 2.055	PHITOT = 18.281
T= .00424	PHI= 193.281	PHIDOT= -1.407	G= -.0413	GDOT= -.197	PSID= 316.081	PSIDOT= 1.217	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= -.923	G= -.0413	GDOT= -.129	PSID= 316.081	PSIDOT= .798	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= -.439	G= -.0413	GDOT= -.062	PSID= 316.081	PSIDOT= .380	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= -.197	G= -.0413	GDOT= -.028	PSID= 316.081	PSIDOT= .170	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .025	G= -.0413	GDOT= .003	PSID= 316.081	PSIDOT= -.022	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .146	G= -.0413	GDOT= .020	PSID= 316.081	PSIDOT= -.125	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .266	G= -.0413	GDOT= .037	PSID= 316.081	PSIDOT= -.228	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .507	G= -.0413	GDOT= .070	PSID= 316.081	PSIDOT= -.435	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .749	G= -.0413	GDOT= .104	PSID= 316.081	PSIDOT= -.641	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .989	G= -.0413	GDOT= .137	PSID= 316.081	PSIDOT= -.847	PHITOT = 18.281
T= .00426	PHI= 193.281	PHIDOT= 1.219	G= -.0413	GDOT= .171	PSID= 316.081	PSIDOT= -1.054	PHITOT = 18.281
T= .00426	PHI= 193.281	PHIDOT= 1.696	G= -.0413	GDOT= .238	PSID= 316.081	PSIDOT= -1.467	PHITOT = 18.281
T= .00426	PHI= 193.282	PHIDOT= 2.174	G= -.0413	GDOT= .305	PSID= 316.080	PSIDOT= -1.880	PHITOT = 18.282
T= .00427	PHI= 193.283	PHIDOT= 3.128	G= -.0413	GDOT= .439	PSID= 316.079	PSIDOT= -2.705	PHITOT = 18.283
T= .00427	PHI= 193.284	PHIDOT= 4.084	G= -.0413	GDOT= .573	PSID= 316.078	PSIDOT= -3.532	PHITOT = 18.284
T= .00429	PHI= 193.287	PHIDOT= 5.993	G= -.0413	GDOT= .840	PSID= 316.075	PSIDOT= -5.183	PHITOT = 18.287

T=	.00430	PHI= 193.292	PHIDOT= 7.901	G=	-.0413	GDOT=	1.108	PSID= 316.071	PSIDOT= -6.835	PHITOT =	18.292		
T=	.00432	PHI= 193.366	PHIDOT= 11.719	G=	-.0413	GDOT=	1.643	PSID= 316.059	PSIDOT= -10.137	PHITOT =	18.306		
T=	.00435	PHI= 193.326	PHIDOT= 15.513	G=	-.0412	GDOT=	2.178	PSID= 316.042	PSIDOT= -13.439	PHITOT =	18.326		
T=	.00440	PHI= 193.391	PHIDOT= 23.07=	G=	-.0411	GDOT=	3.244	PSID= 315.994	PSIDOT= -20.037	PHITOT =	18.361		
T=	.00445	PHI= 193.458	PHIDOT= 30.573	G=	-.0409	GDOT=	4.306	PSID= 315.927	PSIDOT= -26.627	PHITOT =	18.458		
T=	.00450	PHI= 193.556	PHIDOT= 37.971	G=	-.0407	GDOT=	5.363	PSID= 315.841	PSIDOT= -33.206	PHITOT =	18.556		
T=	.00455	PHI= 193.676	PHIDOT= 45.25=	G=	-.0404	GDOT=	6.411	PSID= 315.737	PSIDOT= -39.770	PHITOT =	18.676		
T=	.00465	PHI= 193.976	PHIDOT= 59.394	G=	-.0396	GDOT=	8.481	PSID= 315.473	PSIDOT= -52.845	PHITOT =	18.976		
T=	.00475	PHI= 194.355	PHIDOT= 72.82>	G=	-.0387	GDOT=	10.506	PSID= 315.131	PSIDOT= -65.826	PHITOT =	19.355		
T=	.00485	PHI= 194.809	PHIDOT= 85.39>	G=	-.0375	GDOT=	12.476	PSID= 314.717	PSIDOT= -78.685	PHITOT =	19.809		
T=	.00495	PHI= 195.331	PHIDOT= 96.971	G=	-.0362	GDOT=	14.382	PSID= 314.230	PSIDOT= -91.392	PHITOT =	20.331		
T=	.00505	PHI= 195.918	PHIDOT= 107.454	G=	-.0347	GDOT=	16.216	PSID= 313.670	PSIDOT=-103.916	PHITOT =	20.918		
T=	.00515	PHI= 196.561	PHIDOT= 116.754	G=	-.0329	GDOT=	17.971	PSID= 313.040	PSIDOT=-116.222	PHITOT =	21.561		
T=	.00525	PHI= 197.253	PHIDOT= 124.804	G=	-.0311	GDOT=	19.642	PSID= 312.339	PSIDOT=-128.276	PHITOT =	22.253		
T=	.00535	PHI= 197.986	PHIDOT= 131.564	G=	-.0290	GDOT=	21.223	PSID= 311.570	PSIDOT=-140.042	PHITOT =	22.988		
T=	.00545	PHI= 198.758	PHIDOT= 137.014	G=	-.0268	GDOT=	22.710	PSID= 310.735	PSIDOT=-151.482	PHITOT =	23.758		
T=	.00555	PHI= 199.556	PHIDOT= 141.154	G=	-.0245	GDOT=	24.101	PSID= 309.835	PSIDOT=-162.562	PHITOT =	24.556		
T=	.00565	PHI= 200.373	PHIDOT= 144.017	G=	-.0220	GDOT=	25.392	PSID= 308.873	PSIDOT=-173.248	PHITOT =	25.373		
T=	.00575	PHI= 201.204	PHIDOT= 145.627	G=	-.0194	GDOT=	26.582	PSID= 307.851	PSIDOT=-183.506	PHITOT =	26.204		
T=	.00585	PHI= 202.040	PHIDOT= 146.055	G=	-.0167	GDOT=	27.671	PSID= 306.771	PSIDOT=-193.307	PHITOT =	27.040		
T=	.00595	PHI= 202.875	PHIDOT= 145.376	G=	-.0139	GDOT=	28.656	PSID= 305.637	PSIDOT=-202.626	PHITOT =	27.875		
T=	.00605	PHI= 203.704	PHIDOT= 143.654	G=	-.0110	GDOT=	29.540	PSID= 304.450	PSIDOT=-211.440	PHITOT =	28.704		
T=	.00615	PHI= 204.520	PHIDOT= 141.006	G=	-.0080	GDOT=	30.323	PSID= 303.215	PSIDOT=-219.732	PHITOT =	29.520		
T=	.00625	PHI= 205.318	PHIDOT= 137.505	G=	-.0049	GDOT=	31.006	PSID= 301.933	PSIDOT=-227.487	PHITOT =	30.318		
T=	.00635	PHI= 206.094	PHIDOT= 133.27=	G=	-.0018	GDOT=	31.591	PSID= 300.609	PSIDOT=-234.697	PHITOT =	31.094		
T=	.00645	PHI= 206.844	PHIDOT= 128.397	G=	.0014	GDOT=	32.082	PSID= 299.245	PSIDOT=-241.357	PHITOT =	31.844		
FREE MOTION													
T=	.00645	PHI= 126.844	PHDOT= 128.397	PSI=	48.582	PSIDOT=	-241.357	PHITOT =	31.844				
T=	.00646	PHI= 126.920	PHDOT= 138.808	PSI=	48.444	PSIDOT=	-241.357	PHITOT =	31.920				
T=	.00647	PHI= 127.003	PHDOT= 149.220	PSI=	48.305	PSIDOT=	-241.357	PHITOT =	32.003				
T=	.00648	PHI= 127.091	PHDOT= 159.632	PSI=	48.167	PSIDOT=	-241.357	PHITOT =	32.091				
T=	.00649	PHI= 127.186	PHDOT= 170.044	PSI=	48.029	PSIDOT=	-241.357	PHITOT =	32.186				
T=	.00650	PHI= 127.286	PHDOT= 180.456	PSI=	47.890	PSIDOT=	-241.357	PHITOT =	32.286				
T=	.00651	PHI= 127.393	PHDOT= 190.867	PSI=	47.752	PSIDOT=	-241.357	PHITOT =	32.393				
T=	.00652	PHI= 127.505	PHDOT= 201.279	PSI=	47.614	PSIDOT=	-241.357	PHITOT =	32.505				
T=	.00653	PHI= 127.623	PHDOT= 211.691	PSI=	47.476	PSIDOT=	-241.357	PHITOT =	32.623				
T=	.00654	PHI= 127.747	PHDOT= 222.103	PSI=	47.337	PSIDOT=	-241.357	PHITOT =	32.747				
T=	.00655	PHI= 127.878	PHDOT= 232.514	PSI=	47.199	PSIDOT=	-241.357	PHITOT =	32.878				
T=	.00656	PHI= 128.014	PHDOT= 242.926	PSI=	47.061	PSIDOT=	-241.357	PHITOT =	33.014				
T=	.00657	PHI= 128.156	PHDOT= 253.338	PSI=	46.922	PSIDOT=	-241.357	PHITOT =	33.156				
T=	.00658	PHI= 128.304	PHDOT= 263.750	PSI=	46.784	PSIDOT=	-241.357	PHITOT =	33.304				
T=	.00659	PHI= 128.458	PHDOT= 274.161	PSI=	46.646	PSIDOT=	-241.357	PHITOT =	33.458				
T=	.00660	PHI= 128.618	PHDOT= 284.573	PSI=	46.507	PSIDOT=	-241.357	PHITOT =	33.618				
T=	.00661	PHI= 128.784	PHDOT= 294.985	PSI=	46.369	PSIDOT=	-241.357	PHITOT =	33.784				
T=	.00662	PHI= 128.956	PHDOT= 305.397	PSI=	46.231	PSIDOT=	-241.357	PHITOT =	33.956				
T=	.00663	PHI= 129.134	PHDOT= 315.808	PSI=	46.093	PSIDOT=	-241.357	PHITOT =	34.134				
T=	.00664	PHI= 129.318	PHDOT= 326.220	PSI=	45.954	PSIDOT=	-241.357	PHITOT =	34.318				
T=	.00665	PHI= 129.508	PHDOT= 336.632	PSI=	45.816	PSIDOT=	-241.357	PHITOT =	34.508				
T=	.00666	PHI= 129.704	PHDOT= 347.044	PSI=	45.678	PSIDOT=	-241.357	PHITOT =	34.704				
T=	.00667	PHI= 129.906	PHDOT= 357.456	PSI=	45.539	PSIDOT=	-241.357	PHITOT =	34.906				
T=	.00668	PHI= 130.114	PHDOT= 367.867	PSI=	45.401	PSIDOT=	-241.357	PHITOT =	35.114				
T=	.00669	PHI= 130.327	PHDOT= 378.279	PSI=	45.263	PSIDOT=	-241.357	PHITOT =	35.327				
T=	.00670	PHI= 130.547	PHDOT= 388.691	PSI=	45.125	PSIDOT=	-241.357	PHITOT =	35.547				
T=	.00671	PHI= 130.773	PHDOT= 399.103	PSI=	44.986	PSIDOT=	-241.357	PHITOT =	35.773				
T=	.00672	PHI= 131.004	PHDOT= 409.514	PSI=	44.848	PSIDOT=	-241.357	PHITOT =	36.004				
T=	.00673	PHI= 131.242	PHDOT= 419.926	PSI=	44.710	PSIDOT=	-241.357	PHITOT =	36.242				
T=	.00674	PHI= 131.486	PHDOT= 430.338	PSI=	44.571	PSIDOT=	-241.357	PHITOT =	36.486				
T=	.00675	PHI= 131.735	PHDOT= 440.750	PSI=	44.433	PSIDOT=	-241.357	PHITOT =	36.735				
T=	.00676	PHI= 131.991	PHDOT= 451.161	PSI=	44.295	PSIDOT=	-241.357	PHITOT =	36.991				
T=	.00677	PHI= 132.252	PHDOT= 461.573	PSI=	44.157	PSIDOT=	-241.357	PHITOT =	37.252				
T=	.00678	PHI= 132.520	PHDOT= 471.985	PSI=	44.018	PSIDOT=	-241.357	PHITOT =	37.520				
T=	.00679	PHI= 132.793	PHDOT= 482.397	PSI=	43.880	PSIDOT=	-241.357	PHITOT =	37.793				

```
        T=  .00680   PHI= 133.072   PHDOT= 492.808   PSI=  43.742   PSIDOT=-241.357   PHITOT =  38.072
        T=  .00681   PHI= 133.358   PHDOT= 503.226   PSI=  43.603   PSIDOT=-241.357   PHITOT =  38.358
        T=  .00682   PHI= 133.649   PHDOT= 513.612   PSI=  43.465   PSIDOT=-241.357   PHITOT =  38.649
        T=  .00683   PHI= 133.946   PHDOT= 524.044   PSI=  43.327   PSIDOT=-241.357   PHITOT =  38.946
        T=  .00684   PHI= 134.250   PHDOT= 534.456   PSI=  43.189   PSIDOT=-241.357   PHITOT =  39.250
        T=  .00685   PHI= 134.559   PHDOT= 544.867   PSI=  43.050   PSIDOT=-241.357   PHITOT =  39.559
        T=  .00686   PHI= 134.874   PHDOT= 555.279   PSI=  42.912   PSIDOT=-241.357   PHITOT =  39.874
        T=  .00687   PHI= 135.195   PHDOT= 565.691   PSI=  42.774   PSIDOT=-241.357   PHITOT =  40.195
        T=  .00688   PHI= 135.522   PHDOT= 576.103   PSI=  42.635   PSIDOT=-241.357   PHITOT =  40.522
  VP= -14.102   VS=  44.718

        IMPACT    Cycle No. 2

                  PHI= 135.522   DPHIF=-280.455   PSI=  42.635   DPSIF=-120.910   PHITOT=  40.522
  VP=  -7.044   VS= -21.769

        FREE MOTION
        T=  .00688   PHI= 135.522   PHDOT=-280.455   PSI=  42.635   PSIDOT=-120.910   PHITOT =  40.522
        T=  .00689   PHI= 135.365   PHDOT=-270.043   PSI=  42.566   PSIDOT=-120.910   PHITOT =  40.365
  VP=  -7.079   VS= -20.800

        FREE MOTION
        T=  .00689   PHI= 135.365   PHDOT=-270.043   PSI=  42.566   PSIDOT=-120.910   PHITOT =  40.365
        T=  .00690   PHI= 135.213   PHDOT=-259.631   PSI=  42.497   PSIDOT=-120.910   PHITOT =  40.213
  VP=  -7.092   VS= -19.850

        FREE MOTION
        T=  .00690   PHI= 135.213   PHDOT=-259.631   PSI=  42.497   PSIDOT=-120.910   PHITOT =  40.213
        T=  .00691   PHI= 135.067   PHDOT=-249.220   PSI=  42.428   PSIDOT=-120.910   PHITOT =  40.067
  VP=  -7.105   VS= -18.918

        FREE MOTION
        T=  .00691   PHI= 135.067   PHDOT=-249.220   PSI=  42.428   PSIDOT=-120.910   PHITOT =  40.067
        T=  .00692   PHI= 134.927   PHDOT=-238.808   PSI=  42.358   PSIDOT=-120.910   PHITOT =  39.927
        T=  .00693   PHI= 134.793   PHDOT=-228.396   PSI=  42.289   PSIDOT=-120.910   PHITOT =  39.793
        T=  .00694   PHI= 134.665   PHDOT=-217.984   PSI=  42.220   PSIDOT=-120.910   PHITOT =  39.665
        T=  .00695   PHI= 134.544   PHDOT=-207.573   PSI=  42.151   PSIDOT=-120.910   PHITOT =  39.544
        T=  .00696   PHI= 134.428   PHDOT=-197.161   PSI=  42.081   PSIDOT=-120.910   PHITOT =  39.428
        T=  .00697   PHI= 134.318   PHDOT=-186.749   PSI=  42.012   PSIDOT=-120.910   PHITOT =  39.318

        T=  .00698   PHI= 134.214   PHDOT=-176.337   PSI=  41.943   PSIDOT=-120.910   PHITOT =  39.214
        T=  .00699   PHI= 134.116   PHDOT=-165.926   PSI=  41.873   PSIDOT=-120.910   PHITOT =  39.116
        T=  .00700   PHI= 134.023   PHDOT=-155.514   PSI=  41.804   PSIDOT=-120.910   PHITOT =  39.023
        T=  .00701   PHI= 133.937   PHDOT=-145.102   PSI=  41.735   PSIDOT=-120.910   PHITOT =  38.937
        T=  .00702   PHI= 133.857   PHDOT=-134.690   PSI=  41.666   PSIDOT=-120.910   PHITOT =  38.857
        T=  .00703   PHI= 133.783   PHDOT=-124.278   PSI=  41.596   PSIDOT=-120.910   PHITOT =  38.783
        T=  .00704   PHI= 133.715   PHDOT=-113.867   PSI=  41.527   PSIDOT=-120.910   PHITOT =  38.715
        T=  .00705   PHI= 133.653   PHDOT=-103.455   PSI=  41.458   PSIDOT=-120.910   PHITOT =  38.653
        T=  .00706   PHI= 133.596   PHDOT=  -93.043   PSI=  41.388   PSIDOT=-120.910   PHITOT =  38.596
        T=  .00707   PHI= 133.546   PHDOT=  -82.631   PSI=  41.319   PSIDOT=-120.910   PHITOT =  38.546
        T=  .00708   PHI= 133.502   PHDOT=  -72.220   PSI=  41.250   PSIDOT=-120.910   PHITOT =  38.502
        T=  .00709   PHI= 133.463   PHDOT=  -61.808   PSI=  41.181   PSIDOT=-120.910   PHITOT =  38.463
        T=  .00710   PHI= 133.431   PHDOT=  -51.396   PSI=  41.111   PSIDOT=-120.910   PHITOT =  38.431
        T=  .00711   PHI= 133.404   PHDOT=  -40.984   PSI=  41.042   PSIDOT=-120.910   PHITOT =  38.404
        T=  .00712   PHI= 133.384   PHDOT=  -30.573   PSI=  40.973   PSIDOT=-120.910   PHITOT =  38.384
        T=  .00713   PHI= 133.369   PHDOT=  -20.161   PSI=  40.904   PSIDOT=-120.910   PHITOT =  38.369
        T=  .00714   PHI= 133.361   PHDOT=   -9.749   PSI=  40.834   PSIDOT=-120.910   PHITOT =  38.361
        T=  .00715   PHI= 133.358   PHDOT=     .663   PSI=  40.765   PSIDOT=-120.910   PHITOT =  38.358
        T=  .00716   PHI= 133.361   PHDOT=   11.074   PSI=  40.696   PSIDOT=-120.910   PHITOT =  38.361
        T=  .00717   PHI= 133.371   PHDOT=   21.486   PSI=  40.626   PSIDOT=-120.910   PHITOT =  38.371
        T=  .00718   PHI= 133.386   PHDOT=   31.898   PSI=  40.557   PSIDOT=-120.910   PHITOT =  38.386
        T=  .00719   PHI= 133.407   PHDOT=   42.310   PSI=  40.488   PSIDOT=-120.910   PHITOT =  38.407
        T=  .00720   PHI= 133.435   PHDOT=   52.722   PSI=  40.419   PSIDOT=-120.910   PHITOT =  38.435
  VP=  -7.043   VS=   3.684

        IMPACT
```

PHI= 133.435 DPHIF=-117.116 PSI= 40.419 DPSIF= -94.464 PHITOT= 38.435

VP= -5.503 VS= -8.145

FREE MOTION

T= .00720	PHI= 133.435	PHIDOT=-117.116	PSI= 40.419	PSIDOT= -94.464	PHITOT = 38.435			
T= .00721	PHI= 133.370	PHIDOT=-106.704	PSI= 40.366	PSIDOT= -94.464	PHITOT = 38.370			

VP= -5.504 VS= -7.432

FREE MOTION

T= .00721	PHI= 133.370	PHIDOT=-106.704	PSI= 40.366	PSIDOT= -94.464	PHITOT = 38.370			
T= .00722	PHI= 133.312	PHIDOT= -96.292	PSI= 40.310	PSIDOT= -94.464	PHITOT = 38.312			

VP= -5.505 VS= -6.687

FREE MOTION

T= .00722	PHI= 133.312	PHIDOT= -96.292	PSI= 40.310	PSIDOT= -94.464	PHITOT = 38.312			
T= .00723	PHI= 133.260	PHIDOT= -85.880	PSI= 40.256	PSIDOT= -94.464	PHITOT = 38.260			

VP= -5.504 VS= -5.947

FREE MOTION

T= .00723	PHI= 133.260	PHIDOT= -85.880	PSI= 40.256	PSIDOT= -94.464	PHITOT = 38.260			
T= .00724	PHI= 133.214	PHIDOT= -75.468	PSI= 40.202	PSIDOT= -94.464	PHITOT = 38.214			

VP= -5.503 VS= -5.214

IMPACT

PHI= 133.214 DPHIF= -80.092 PSI= 40.202 DPSIF= -93.736 PHITOT= 38.214

VP= -5.461 VS= -5.533

COUPLED MOTION

T= .00724	PHI= 133.214	PHIDOT= -80.092	G= -.0522	GDOT= -16.592	PSID= 40.204	PSIDOT= -94.974	PHITOT = 38.214					
T= .00734	PHI= 132.830	PHIDOT= -53.464	G= -.0536	GDOT= -10.990	PSID= 39.756	PSIDOT= -62.227	PHITOT = 37.830					
T= .00744	PHI= 132.604	PHIDOT= -25.344	G= -.0544	GDOT= -5.186	PSID= 39.492	PSIDOT= -29.172	PHITOT = 37.604					
T= .00746	PHI= 132.573	PHIDOT= -18.176	G= -.0545	GDOT= -3.715	PSID= 39.456	PSIDOT= -20.880	PHITOT = 37.573					
T= .00749	PHI= 132.552	PHIDOT= -10.961	G= -.0546	GDOT= -2.240	PSID= 39.432	PSIDOT= -12.582	PHITOT = 37.552					
T= .00750	PHI= 132.545	PHIDOT= -7.344	G= -.0546	GDOT= -1.501	PSID= 39.424	PSIDOT= -8.432	PHITOT = 37.545					
T= .00751	PHI= 132.541	PHIDOT= -3.731	G= -.0547	GDOT= -.762	PSID= 39.420	PSIDOT= -4.281	PHITOT = 37.541					
T= .00752	PHI= 132.540	PHIDOT= -1.923	G= -.0547	GDOT= -.393	PSID= 39.419	PSIDOT= -2.205	PHITOT = 37.540					
T= .00753	PHI= 132.540	PHIDOT= -.117	G= -.0547	GDOT= -.023	PSID= 39.418	PSIDOT= -.129	PHITOT = 37.540					
T= .00753	PHI= 132.540	PHIDOT= .091	G= -.0547	GDOT= .019	PSID= 39.418	PSIDOT= .105	PHITOT = 37.540					
T= .00753	PHI= 132.540	PHIDOT= .171	G= -.0547	GDOT= .035	PSID= 39.418	PSIDOT= .196	PHITOT = 37.540					
T= .00753	PHI= 132.540	PHIDOT= .251	G= -.0547	GDOT= .051	PSID= 39.418	PSIDOT= .288	PHITOT = 37.540					
T= .00753	PHI= 132.540	PHIDOT= .331	G= -.0547	GDOT= .068	PSID= 39.418	PSIDOT= .379	PHITOT = 37.540					
T= .00754	PHI= 132.540	PHIDOT= .491	G= -.0547	GDOT= .100	PSID= 39.418	PSIDOT= .562	PHITOT = 37.540					
T= .00754	PHI= 132.540	PHIDOT= .650	G= -.0547	GDOT= .133	PSID= 39.418	PSIDOT= .745	PHITOT = 37.540					
T= .00755	PHI= 132.541	PHIDOT= .969	G= -.0547	GDOT= .198	PSID= 39.419	PSIDOT= 1.111	PHITOT = 37.541					
T= .00755	PHI= 132.541	PHIDOT= 1.288	G= -.0547	GDOT= .263	PSID= 39.419	PSIDOT= 1.477	PHITOT = 37.541					
T= .00756	PHI= 132.542	PHIDOT= 1.607	G= -.0547	GDOT= .328	PSID= 39.420	PSIDOT= 1.843	PHITOT = 37.542					
T= .00756	PHI= 132.542	PHIDOT= 1.924	G= -.0547	GDOT= .393	PSID= 39.421	PSIDOT= 2.209	PHITOT = 37.542					
T= .00758	PHI= 132.544	PHIDOT= 2.561	G= -.0546	GDOT= .524	PSID= 39.422	PSIDOT= 2.941	PHITOT = 37.544					
T= .00759	PHI= 132.546	PHIDOT= 3.201	G= -.0546	GDOT= .654	PSID= 39.425	PSIDOT= 3.673	PHITOT = 37.546					
T= .00761	PHI= 132.551	PHIDOT= 4.475	G= -.0546	GDOT= .915	PSID= 39.431	PSIDOT= 5.137	PHITOT = 37.551					
T= .00764	PHI= 132.559	PHIDOT= 5.748	G= -.0546	GDOT= 1.175	PSID= 39.439	PSIDOT= 6.601	PHITOT = 37.559					
T= .00769	PHI= 132.579	PHIDOT= 8.284	G= -.0545	GDOT= 1.695	PSID= 39.463	PSIDOT= 9.527	PHITOT = 37.579					
T= .00774	PHI= 132.606	PHIDOT= 10.814	G= -.0544	GDOT= 2.213	PSID= 39.494	PSIDOT= 12.453	PHITOT = 37.606					
T= .00779	PHI= 132.641	PHIDOT= 13.335	G= -.0543	GDOT= 2.730	PSID= 39.534	PSIDOT= 15.376	PHITOT = 37.641					
T= .00784	PHI= 132.683	PHIDOT= 15.836	G= -.0542	GDOT= 3.245	PSID= 39.582	PSIDOT= 18.297	PHITOT = 37.683					
T= .00794	PHI= 132.787	PHIDOT= 20.777	G= -.0538	GDOT= 4.247	PSID= 39.704	PSIDOT= 24.131	PHITOT = 37.787					
T= .00804	PHI= 132.920	PHIDOT= 25.628	G= -.0533	GDOT= 5.276	PSID= 39.859	PSIDOT= 29.952	PHITOT = 37.920					
T= .00814	PHI= 133.081	PHIDOT= 30.347	G= -.0527	GDOT= 6.270	PSID= 40.047	PSIDOT= 35.756	PHITOT = 38.081					
T= .00824	PHI= 133.268	PHIDOT= 34.941	G= -.0520	GDOT= 7.244	PSID= 40.268	PSIDOT= 41.540	PHITOT = 38.268					
T= .00834	PHI= 133.481	PHIDOT= 39.387	G= -.0513	GDOT= 8.203	PSID= 40.523	PSIDOT= 47.303	PHITOT = 38.481					
T= .00844	PHI= 133.719	PHIDOT= 43.675	G= -.0504	GDOT= 9.139	PSID= 40.810	PSIDOT= 53.043	PHITOT = 38.719					
T= .00854	PHI= 133.981	PHIDOT= 47.798	G= -.0496	GDOT= 10.053	PSID= 41.131	PSIDOT= 58.756	PHITOT = 38.981					
T= .00864	PHI= 134.266	PHIDOT= 51.749	G= -.0484	GDOT= 10.944	PSID= 41.484	PSIDOT= 64.442	PHITOT = 39.266					

T=	.00874	PHI= 134.574	PHIDOT= 55.527	G=	-.0473	GDOT= 11.811	PSID= 41.869	PSIDOT= 70.100	PHITOT = 39.574				
T=	.00884	PHI= 134.902	PHIDOT= 59.133	G=	-.0460	GDOT= 12.654	PSID= 42.287	PSIDOT= 75.729	PHITOT = 39.902				
T=	.00894	PHI= 135.251	PHIDOT= 62.965	G=	-.0447	GDOT= 13.472	PSID= 42.737	PSIDOT= 81.328	PHITOT = 40.251				
T=	.00904	PHI= 135.619	PHIDOT= 65.831	G=	-.0433	GDOT= 14.267	PSID= 43.219	PSIDOT= 86.897	PHITOT = 40.619				
T=	.00914	PHI= 136.005	PHIDOT= 68.934	G=	-.0419	GDOT= 15.038	PSID= 43.733	PSIDOT= 92.437	PHITOT = 41.005				
T=	.00924	PHI= 136.409	PHIDOT= 71.883	G=	-.0403	GDOT= 15.786	PSID= 44.278	PSIDOT= 97.948	PHITOT = 41.409				
T=	.00934	PHI= 136.829	PHIDOT= 74.685	G=	-.0387	GDOT= 16.512	PSID= 44.855	PSIDOT= 103.431	PHITOT = 41.829				
T=	.00944	PHI= 137.264	PHIDOT= 77.348	G=	-.0370	GDOT= 17.216	PSID= 45.463	PSIDOT= 108.886	PHITOT = 42.264				
T=	.00954	PHI= 137.715	PHIDOT= 79.881	G=	-.0353	GDOT= 17.899	PSID= 46.103	PSIDOT= 114.317	PHITOT = 42.715				
T=	.00964	PHI= 138.179	PHIDOT= 82.294	G=	-.0335	GDOT= 18.562	PSID= 46.773	PSIDOT= 119.723	PHITOT = 43.179				
T=	.00974	PHI= 138.657	PHIDOT= 84.595	G=	-.0316	GDOT= 19.206	PSID= 47.474	PSIDOT= 125.106	PHITOT = 43.657				
T=	.00984	PHI= 139.148	PHIDOT= 86.795	G=	-.0296	GDOT= 19.831	PSID= 48.207	PSIDOT= 130.470	PHITOT = 44.148				
T=	.00994	PHI= 139.652	PHIDOT= 88.903	G=	-.0276	GDOT= 20.438	PSID= 48.969	PSIDOT= 135.815	PHITOT = 44.652				
T=	.01004	PHI= 140.167	PHIDOT= 90.924	G=	-.0255	GDOT= 21.029	PSID= 49.763	PSIDOT= 141.143	PHITOT = 45.167				
T=	.01014	PHI= 140.694	PHIDOT= 92.874	G=	-.0234	GDOT= 21.603	PSID= 50.587	PSIDOT= 146.458	PHITOT = 45.694				
T=	.01024	PHI= 141.231	PHIDOT= 94.754	G=	-.0212	GDOT= 22.162	PSID= 51.441	PSIDOT= 151.761	PHITOT = 46.231				
T=	.01034	PHI= 141.779	PHIDOT= 96.575	G=	-.0190	GDOT= 22.706	PSID= 52.326	PSIDOT= 157.055	PHITOT = 46.779				
T=	.01044	PHI= 142.338	PHIDOT= 98.343	G=	-.0167	GDOT= 23.235	PSID= 53.241	PSIDOT= 162.341	PHITOT = 47.338				
T=	.01054	PHI= 142.906	PHIDOT= 100.065	G=	-.0143	GDOT= 23.750	PSID= 54.186	PSIDOT= 167.622	PHITOT = 47.906				
T=	.01064	PHI= 143.484	PHIDOT= 101.747	G=	-.0119	GDOT= 24.252	PSID= 55.162	PSIDOT= 172.901	PHITOT = 48.484				
T=	.01074	PHI= 144.072	PHIDOT= 103.396	G=	-.0095	GDOT= 24.740	PSID= 56.167	PSIDOT= 178.179	PHITOT = 49.072				
T=	.01084	PHI= 144.669	PHIDOT= 105.017	G=	-.0070	GDOT= 25.214	PSID= 57.203	PSIDOT= 183.459	PHITOT = 49.669				
T=	.01094	PHI= 145.275	PHIDOT= 106.607	G=	-.0044	GDOT= 25.676	PSID= 58.270	PSIDOT= 188.742	PHITOT = 50.275				
T=	.01104	PHI= 145.891	PHIDOT= 108.181	G=	-.0018	GDOT= 26.124	PSID= 59.366	PSIDOT= 194.031	PHITOT = 50.891				
T=	.01114	PHI= 146.515	PHIDOT= 109.739	G=	.0008	GDOT= 26.559	PSID= 60.493	PSIDOT= 199.328	PHITOT = 51.515				

FREE MOTION

T=	.01114	PHI= 146.515	PHIDOT= 109.739	PSI= 311.156	PSIDOT= 199.328	PHITOT = 51.515							
T=	.01115	PHI= 146.581	PHIDOT= 120.151	PSI= 311.270	PSIDOT= 199.328	PHITOT = 51.581							
T=	.01116	PHI= 146.653	PHIDOT= 130.563	PSI= 311.385	PSIDOT= 199.328	PHITOT = 51.653							
T=	.01117	PHI= 146.730	PHIDOT= 140.974	PSI= 311.499	PSIDOT= 199.328	PHITOT = 51.730							
T=	.01118	PHI= 146.814	PHIDOT= 151.386	PSI= 311.613	PSIDOT= 199.328	PHITOT = 51.814							
T=	.01119	PHI= 146.904	PHIDOT= 161.798	PSI= 311.727	PSIDOT= 199.328	PHITOT = 51.904							
T=	.01120	PHI= 147.000	PHIDOT= 172.210	PSI= 311.841	PSIDOT= 199.328	PHITOT = 52.000							
T=	.01121	PHI= 147.101	PHIDOT= 182.621	PSI= 311.956	PSIDOT= 199.328	PHITOT = 52.101							
T=	.01122	PHI= 147.209	PHIDOT= 193.033	PSI= 312.070	PSIDOT= 199.328	PHITOT = 52.209							
T=	.01123	PHI= 147.322	PHIDOT= 203.445	PSI= 312.184	PSIDOT= 199.328	PHITOT = 52.322							
T=	.01124	PHI= 147.442	PHIDOT= 213.857	PSI= 312.298	PSIDOT= 199.328	PHITOT = 52.442							
T=	.01125	PHI= 147.568	PHIDOT= 224.268	PSI= 312.412	PSIDOT= 199.328	PHITOT = 52.568							
T=	.01126	PHI= 147.699	PHIDOT= 234.680	PSI= 312.527	PSIDOT= 199.328	PHITOT = 52.699							
T=	.01127	PHI= 147.836	PHIDOT= 245.092	PSI= 312.641	PSIDOT= 199.328	PHITOT = 52.836							
T=	.01128	PHI= 147.980	PHIDOT= 255.504	PSI= 312.755	PSIDOT= 199.328	PHITOT = 52.980							
T=	.01129	PHI= 148.129	PHIDOT= 265.915	PSI= 312.869	PSIDOT= 199.328	PHITOT = 53.129							
T=	.01130	PHI= 148.285	PHIDOT= 276.327	PSI= 312.984	PSIDOT= 199.328	PHITOT = 53.285							
T=	.01131	PHI= 148.446	PHIDOT= 286.739	PSI= 313.098	PSIDOT= 199.328	PHITOT = 53.446							
T=	.01132	PHI= 148.613	PHIDOT= 297.151	PSI= 313.212	PSIDOT= 199.328	PHITOT = 53.613							
T=	.01133	PHI= 148.786	PHIDOT= 307.563	PSI= 313.326	PSIDOT= 199.328	PHITOT = 53.786							
T=	.01134	PHI= 148.966	PHIDOT= 317.974	PSI= 313.440	PSIDOT= 199.328	PHITOT = 53.966							
T=	.01135	PHI= 149.151	PHIDOT= 328.386	PSI= 313.555	PSIDOT= 199.328	PHITOT = 54.151							
T=	.01136	PHI= 149.342	PHIDOT= 338.798	PSI= 313.669	PSIDOT= 199.328	PHITOT = 54.342							
T=	.01137	PHI= 149.539	PHIDOT= 349.210	PSI= 313.783	PSIDOT= 199.328	PHITOT = 54.539							
T=	.01138	PHI= 149.742	PHIDOT= 359.621	PSI= 313.897	PSIDOT= 199.328	PHITOT = 54.742							
T=	.01139	PHI= 149.951	PHIDOT= 370.033	PSI= 314.011	PSIDOT= 199.328	PHITOT = 54.951							
T=	.01140	PHI= 150.166	PHIDOT= 380.445	PSI= 314.126	PSIDOT= 199.328	PHITOT = 55.166							
T=	.01141	PHI= 150.387	PHIDOT= 390.857	PSI= 314.240	PSIDOT= 199.328	PHITOT = 55.387							
T=	.01142	PHI= 150.614	PHIDOT= 401.268	PSI= 314.354	PSIDOT= 199.328	PHITOT = 55.614							
T=	.01143	PHI= 150.847	PHIDOT= 411.680	PSI= 314.468	PSIDOT= 199.328	PHITOT = 55.847							
T=	.01144	PHI= 151.086	PHIDOT= 422.092	PSI= 314.582	PSIDOT= 199.328	PHITOT = 56.086							
T=	.01145	PHI= 151.331	PHIDOT= 432.504	PSI= 314.697	PSIDOT= 199.328	PHITOT = 56.331							
T=	.01146	PHI= 151.581	PHIDOT= 442.915	PSI= 314.811	PSIDOT= 199.328	PHITOT = 56.581							
T=	.01147	PHI= 151.838	PHIDOT= 453.327	PSI= 314.925	PSIDOT= 199.328	PHITOT = 56.838							
T=	.01148	PHI= 152.101	PHIDOT= 463.739	PSI= 315.039	PSIDOT= 199.328	PHITOT = 57.101							
T=	.01149	PHI= 152.370	PHIDOT= 474.151	PSI= 315.153	PSIDOT= 199.328	PHITOT = 57.370							
T=	.01150	PHI= 152.644	PHIDOT= 484.563	PSI= 315.268	PSIDOT= 199.328	PHITOT = 57.644							
T=	.01151	PHI= 152.925	PHIDOT= 494.974	PSI= 315.382	PSIDOT= 199.328	PHITOT = 57.925							
T=	.01152	PHI= 153.211	PHIDOT= 505.386	PSI= 315.496	PSIDOT= 199.328	PHITOT = 58.211							

```
        T=  .01153   PHI= 193.504   PHDOT= 515.798   PSI= 315.610   PSIDOT= 199.328   PHITOT =  58.504
        T=  .01154   PHI= 193.802   PHDOT= 526.210   PSI= 315.724   PSIDOT= 199.328   PHITOT =  58.802
  VP= -18.348   VS=  42.763

      IMPACT

                     PHI= 193.802   DPHIF=-232.037   PSI= 315.724   DPSIF=  38.881   PHITOT=  58.802
  VP=  -3.579   VS= -18.857

      FREE MOTION
        T=  .01154   PHI= 193.802   PHDOT=-232.037   PSI= 315.724   PSIDOT=  38.881   PHITOT =  58.802
        T=  .01155   PHI= 193.672   PHDOT=-221.626   PSI= 315.747   PSIDOT=  38.881   PHITOT =  58.672
  VP=  -3.582   VS= -17.939

      FREE MOTION
        T=  .01155   PHI= 193.672   PHDOT=-221.626   PSI= 315.747   PSIDOT=  38.881   PHITOT =  58.672
        T=  .01156   PHI= 193.548   PHDOT=-211.214   PSI= 315.769   PSIDOT=  38.881   PHITOT =  58.548
        T=  .01157   PHI= 193.430   PHDOT=-200.802   PSI= 315.791   PSIDOT=  38.881   PHITOT =  58.430
        T=  .01158   PHI= 193.314   PHDOT=-190.390   PSI= 315.814   PSIDOT=  38.881   PHITOT =  58.318
        T=  .01159   PHI= 193.212   PHDOT=-179.979   PSI= 315.836   PSIDOT=  38.881   PHITOT =  58.212
        T=  .01160   PHI= 193.112   PHDOT=-169.567   PSI= 315.858   PSIDOT=  38.881   PHITOT =  58.112
        T=  .01161   PHI= 193.018   PHDOT=-159.155   PSI= 315.880   PSIDOT=  38.881   PHITOT =  58.018
        T=  .01162   PHI= 192.930   PHDOT=-148.743   PSI= 315.903   PSIDOT=  38.881   PHITOT =  57.930
        T=  .01163   PHI= 192.848   PHDOT=-138.332   PSI= 315.925   PSIDOT=  38.881   PHITOT =  57.848
        T=  .01164   PHI= 192.771   PHDOT=-127.920   PSI= 315.947   PSIDOT=  38.881   PHITOT =  57.771
        T=  .01165   PHI= 192.701   PHDOT=-117.508   PSI= 315.970   PSIDOT=  38.881   PHITOT =  57.701
        T=  .01166   PHI= 192.637   PHDOT=-107.096   PSI= 315.992   PSIDOT=  38.881   PHITOT =  57.637
        T=  .01167   PHI= 192.578   PHDOT= -96.685   PSI= 316.014   PSIDOT=  38.881   PHITOT =  57.578
        T=  .01168   PHI= 192.526   PHDOT= -86.273   PSI= 316.036   PSIDOT=  38.881   PHITOT =  57.526
        T=  .01169   PHI= 192.479   PHDOT= -75.861   PSI= 316.059   PSIDOT=  38.881   PHITOT =  57.479
        T=  .01170   PHI= 192.439   PHDOT= -65.449   PSI= 316.081   PSIDOT=  38.881   PHITOT =  57.439
        T=  .01171   PHI= 192.404   PHDOT= -55.037   PSI= 316.103   PSIDOT=  38.881   PHITOT =  57.404
        T=  .01172   PHI= 192.376   PHDOT= -44.626   PSI= 316.125   PSIDOT=  38.881   PHITOT =  57.376
        T=  .01173   PHI= 192.353   PHDOT= -34.214   PSI= 316.148   PSIDOT=  38.881   PHITOT =  57.353
        T=  .01174   PHI= 192.337   PHDOT= -23.802   PSI= 316.170   PSIDOT=  38.881   PHITOT =  57.337
        T=  .01175   PHI= 192.326   PHDOT= -13.390   PSI= 316.192   PSIDOT=  38.881   PHITOT =  57.326
        T=  .01176   PHI= 192.321   PHDOT=  -2.979   PSI= 316.215   PSIDOT=  38.881   PHITOT =  57.321
        T=  .01177   PHI= 192.323   PHDOT=   7.433   PSI= 316.237   PSIDOT=  38.881   PHITOT =  57.323
        T=  .01178   PHI= 192.330   PHDOT=  17.845   PSI= 316.259   PSIDOT=  38.881   PHITOT =  57.330
        T=  .01179   PHI= 192.343   PHDOT=  28.257   PSI= 316.281   PSIDOT=  38.881   PHITOT =  57.343
        T=  .01180   PHI= 192.362   PHDOT=  38.668   PSI= 316.304   PSIDOT=  38.881   PHITOT =  57.362
        T=  .01181   PHI= 192.387   PHDOT=  49.080   PSI= 316.326   PSIDOT=  38.881   PHITOT =  57.387
        T=  .01182   PHI= 192.418   PHDOT=  59.492   PSI= 316.348   PSIDOT=  38.881   PHITOT =  57.418
        T=  .01183   PHI= 192.455   PHDOT=  69.904   PSI= 316.371   PSIDOT=  38.881   PHITOT =  57.455
        T=  .01184   PHI= 192.498   PHDOT=  80.315   PSI= 316.393   PSIDOT=  38.881   PHITOT =  57.498
        T=  .01185   PHI= 192.547   PHDOT=  90.727   PSI= 316.415   PSIDOT=  38.881   PHITOT =  57.547
        T=  .01186   PHI= 192.602   PHDOT= 101.139   PSI= 316.437   PSIDOT=  38.881   PHITOT =  57.602
        T=  .01187   PHI= 192.663   PHDOT= 111.551   PSI= 316.460   PSIDOT=  38.881   PHITOT =  57.663
        T=  .01188   PHI= 192.730   PHDOT= 121.963   PSI= 316.482   PSIDOT=  38.881   PHITOT =  57.730
        T=  .01189   PHI= 192.803   PHDOT= 132.374   PSI= 316.504   PSIDOT=  38.881   PHITOT =  57.803
  VP=  -3.414   VS=  10.434

      IMPACT

                     PHI= 192.803   DPHIF= -44.468   PSI= 316.504   DPSIF=  -.073   PHITOT=  57.803
  VP=    .007   VS=  -3.505

      FREE MOTION
        T=  .01189   PHI= 192.803   PHDOT= -44.468   PSI= 316.504   PSIDOT=  -.073   PHITOT =  57.803
        T=  .01190   PHI= 192.781   PHDOT= -34.057   PSI= 316.504   PSIDOT=  -.073   PHITOT =  57.781
        T=  .01191   PHI= 192.764   PHDOT= -23.645   PSI= 316.504   PSIDOT=  -.073   PHITOT =  57.764
        T=  .01192   PHI= 192.754   PHDOT= -13.233   PSI= 316.504   PSIDOT=  -.073   PHITOT =  57.754
        T=  .01193   PHI= 192.749   PHDOT=  -2.821   PSI= 316.504   PSIDOT=  -.073   PHITOT =  57.749
        T=  .01194   PHI= 192.750   PHDOT=   7.590   PSI= 316.504   PSIDOT=  -.073   PHITOT =  57.750
```

T= .01195 PHI= 192.758 PHIDOT= 18.002 PSI= 316.504 PSIDOT= -.073 PHITOT = 57.758
T= .01196 PHI= 192.771 PHIDOT= 28.414 PSI= 316.504 PSIDOT= -.073 PHITOT = 57.771
T= .01197 PHI= 192.790 PHIDOT= 38.826 PSI= 316.504 PSIDOT= -.073 PHITOT = 57.790

VP= .007 VS= 3.059

IMPACT

PHI= 192.790 DPHIF= .393 PSI= 316.504 DPSIF= -8.543 PHITOT= 57.790

VP= .794 VS= .031

COUPLED MOTION

T= .01197 PHI= 192.790 PHIDOT= .393 G= -.0425 GDOT= .054 PSID= 316.501 PSIDOT= -.333 PHITOT = 57.790
T= .01207 PHI= 192.838 PHIDOT= 16.179 G= -.0424 GDOT= 2.243 PSID= 316.461 PSIDOT= -13.741 PHITOT = 57.838
T= .01217 PHI= 192.975 PHIDOT= 31.769 G= -.0421 GDOT= 4.419 PSID= 316.344 PSIDOT= -27.127 PHITOT = 57.975
T= .01227 PHI= 193.201 PHIDOT= 46.954 G= -.0415 GDOT= 6.570 PSID= 316.150 PSIDOT= -40.468 PHITOT = 58.201
T= .01237 PHI= 193.512 PHIDOT= 61.570 G= -.0408 GDOT= 8.685 PSID= 315.880 PSIDOT= -53.742 PHITOT = 58.512
T= .01247 PHI= 193.905 PHIDOT= 75.440 G= -.0398 GDOT= 10.752 PSID= 315.534 PSIDOT= -66.923 PHITOT = 58.905
T= .01257 PHI= 194.375 PHIDOT= 88.410 G= -.0386 GDOT= 12.762 PSID= 315.113 PSIDOT= -79.984 PHITOT = 59.375
T= .01267 PHI= 194.916 PHIDOT= 100.346 G= -.0373 GDOT= 14.706 PSID= 314.618 PSIDOT= -92.894 PHITOT = 59.916
T= .01277 PHI= 195.523 PHIDOT= 111.135 G= -.0357 GDOT= 16.575 PSID= 314.049 PSIDOT=-105.620 PHITOT = 60.523
T= .01287 PHI= 196.187 PHIDOT= 120.687 G= -.0339 GDOT= 18.363 PSID= 313.408 PSIDOT=-118.127 PHITOT = 61.187
T= .01297 PHI= 196.903 PHIDOT= 128.935 G= -.0320 GDOT= 20.063 PSID= 312.696 PSIDOT=-130.381 PHITOT = 61.903
T= .01307 PHI= 197.662 PHIDOT= 135.834 G= -.0299 GDOT= 21.670 PSID= 311.915 PSIDOT=-142.342 PHITOT = 62.662
T= .01317 PHI= 198.457 PHIDOT= 141.373 G= -.0277 GDOT= 23.181 PSID= 311.066 PSIDOT=-153.974 PHITOT = 63.457
T= .01327 PHI= 199.280 PHIDOT= 145.548 G= -.0253 GDOT= 24.593 PSID= 310.151 PSIDOT=-165.239 PHITOT = 64.280
T= .01337 PHI= 200.122 PHIDOT= 148.386 G= -.0228 GDOT= 25.902 PSID= 309.173 PSIDOT=-176.101 PHITOT = 65.122
T= .01347 PHI= 200.978 PHIDOT= 149.939 G= -.0201 GDOT= 27.107 PSID= 308.134 PSIDOT=-186.527 PHITOT = 65.978
T= .01357 PHI= 201.838 PHIDOT= 150.265 G= -.0174 GDOT= 28.207 PSID= 307.036 PSIDOT=-196.487 PHITOT = 66.838
T= .01367 PHI= 202.697 PHIDOT= 149.439 G= -.0145 GDOT= 29.202 PSID= 305.883 PSIDOT=-205.953 PHITOT = 67.697
T= .01377 PHI= 203.549 PHIDOT= 147.540 G= -.0115 GDOT= 30.093 PSID= 304.677 PSIDOT=-214.902 PHITOT = 68.549
T= .01387 PHI= 204.386 PHIDOT= 144.682 G= -.0085 GDOT= 30.880 PSID= 303.422 PSIDOT=-223.315 PHITOT = 69.386
T= .01397 PHI= 205.205 PHIDOT= 140.961 G= -.0053 GDOT= 31.565 PSID= 302.119 PSIDOT=-231.179 PHITOT = 70.205
T= .01407 PHI= 206.000 PHIDOT= 136.483 G= -.0022 GDOT= 32.151 PSID= 300.774 PSIDOT=-238.486 PHITOT = 71.000
T= .01417 PHI= 206.768 PHIDOT= 131.355 G= .0011 GDOT= 32.638 PSID= 299.388 PSIDOT=-245.226 PHITOT = 71.768

FREE MOTION

T= .01417 PHI= 126.768 PHIDOT= 131.355 PSI= 48.725 PSIDOT=-245.226 PHITOT = 71.768
T= .01418 PHI= 126.846 PHIDOT= 141.766 PSI= 48.584 PSIDOT=-245.226 PHITOT = 71.846
T= .01419 PHI= 126.930 PHIDOT= 152.178 PSI= 48.444 PSIDOT=-245.226 PHITOT = 71.930
T= .01420 PHI= 127.020 PHIDOT= 162.590 PSI= 48.303 PSIDOT=-245.226 PHITOT = 72.020
T= .01421 PHI= 127.116 PHIDOT= 173.002 PSI= 48.163 PSIDOT=-245.226 PHITOT = 72.116
T= .01422 PHI= 127.218 PHIDOT= 183.414 PSI= 48.022 PSIDOT=-245.226 PHITOT = 72.218
T= .01423 PHI= 127.327 PHIDOT= 193.825 PSI= 47.882 PSIDOT=-245.226 PHITOT = 72.327
T= .01424 PHI= 127.441 PHIDOT= 204.237 PSI= 47.741 PSIDOT=-245.226 PHITOT = 72.441
T= .01425 PHI= 127.561 PHIDOT= 214.649 PSI= 47.601 PSIDOT=-245.226 PHITOT = 72.561
T= .01426 PHI= 127.687 PHIDOT= 225.061 PSI= 47.460 PSIDOT=-245.226 PHITOT = 72.687
T= .01427 PHI= 127.818 PHIDOT= 235.472 PSI= 47.320 PSIDOT=-245.226 PHITOT = 72.818
T= .01428 PHI= 127.956 PHIDOT= 245.884 PSI= 47.179 PSIDOT=-245.226 PHITOT = 72.956
T= .01429 PHI= 128.100 PHIDOT= 256.296 PSI= 47.039 PSIDOT=-245.226 PHITOT = 73.100
T= .01430 PHI= 128.250 PHIDOT= 266.708 PSI= 46.898 PSIDOT=-245.226 PHITOT = 73.250
T= .01431 PHI= 128.406 PHIDOT= 277.119 PSI= 46.758 PSIDOT=-245.226 PHITOT = 73.406
T= .01432 PHI= 128.568 PHIDOT= 287.531 PSI= 46.617 PSIDOT=-245.226 PHITOT = 73.568
T= .01433 PHI= 128.735 PHIDOT= 297.943 PSI= 46.476 PSIDOT=-245.226 PHITOT = 73.735
T= .01434 PHI= 128.909 PHIDOT= 308.355 PSI= 46.336 PSIDOT=-245.226 PHITOT = 73.909
T= .01435 PHI= 129.089 PHIDOT= 318.766 PSI= 46.195 PSIDOT=-245.226 PHITOT = 74.089
T= .01436 PHI= 129.274 PHIDOT= 329.178 PSI= 46.055 PSIDOT=-245.226 PHITOT = 74.274
T= .01437 PHI= 129.466 PHIDOT= 339.590 PSI= 45.914 PSIDOT=-245.226 PHITOT = 74.466
T= .01438 PHI= 129.663 PHIDOT= 350.002 PSI= 45.774 PSIDOT=-245.226 PHITOT = 74.663
T= .01439 PHI= 129.867 PHIDOT= 360.414 PSI= 45.633 PSIDOT=-245.226 PHITOT = 74.867
T= .01440 PHI= 130.076 PHIDOT= 370.825 PSI= 45.493 PSIDOT=-245.226 PHITOT = 75.076
T= .01441 PHI= 130.292 PHIDOT= 381.237 PSI= 45.352 PSIDOT=-245.226 PHITOT = 75.292
T= .01442 PHI= 130.513 PHIDOT= 391.649 PSI= 45.212 PSIDOT=-245.226 PHITOT = 75.513
T= .01443 PHI= 130.741 PHIDOT= 402.061 PSI= 45.071 PSIDOT=-245.226 PHITOT = 75.741

T= .01444 PHI= 130.974 PHDOT= 412.472 PSI= 44.931 PSIDOT=-245.226 PHITOT = 75.974
T= .01445 PHI= 131.213 PHDOT= 422.886 PSI= 44.790 PSIDOT=-245.226 PHITOT = 76.213
T= .01446 PHI= 131.459 PHDOT= 433.236 PSI= 44.650 PSIDOT=-245.226 PHITOT = 76.459
T= .01447 PHI= 131.710 PHDOT= 443.708 PSI= 44.509 PSIDOT=-245.226 PHITOT = 76.710
T= .01448 PHI= 131.967 PHDOT= 454.119 PSI= 44.369 PSIDOT=-245.226 PHITOT = 76.967
T= .01449 PHI= 132.230 PHDOT= 464.531 PSI= 44.228 PSIDOT=-245.226 PHITOT = 77.230
T= .01450 PHI= 132.499 PHDOT= 474.943 PSI= 44.088 PSIDOT=-245.226 PHITOT = 77.499
T= .01451 PHI= 132.774 PHDOT= 485.355 PSI= 43.947 PSIDOT=-245.226 PHITOT = 77.774
T= .01452 PHI= 133.056 PHDOT= 495.766 PSI= 43.807 PSIDOT=-245.226 PHITOT = 78.056
T= .01453 PHI= 133.343 PHDOT= 506.178 PSI= 43.666 PSIDOT=-245.226 PHITOT = 78.343
T= .01454 PHI= 133.636 PHDOT= 516.590 PSI= 43.526 PSIDOT=-245.226 PHITOT = 78.636
T= .01455 PHI= 133.935 PHDOT= 527.002 PSI= 43.385 PSIDOT=-245.226 PHITOT = 78.935
T= .01456 PHI= 134.239 PHDOT= 537.414 PSI= 43.245 PSIDOT=-245.226 PHITOT = 79.239
T= .01457 PHI= 134.550 PHDOT= 547.825 PSI= 43.104 PSIDOT=-245.226 PHITOT = 79.550
T= .01458 PHI= 134.867 PHDOT= 558.237 PSI= 42.964 PSIDOT=-245.226 PHITOT = 79.867
T= .01459 PHI= 135.190 PHDOT= 568.649 PSI= 42.823 PSIDOT=-245.226 PHITOT = 80.190
T= .01460 PHI= 135.519 PHDOT= 579.061 PSI= 42.683 PSIDOT=-245.226 PHITOT = 80.519

VP= -14.344 VS= 44.940

IMPACT Cycle No. 3

PHI= 135.519 DPHIF=-284.190 PSI= 42.683 DPSIF=-123.677 PHITOT= 80.519

VP= -7.234 VS= -22.056

FREE MOTION
T= .01460 PHI= 135.519 PHDOT=-284.190 PSI= 42.683 PSIDOT=-123.677 PHITOT = 80.519
T= .01461 PHI= 135.359 PHDOT=-273.779 PSI= 42.612 PSIDOT=-123.677 PHITOT = 80.359

VP= -7.249 VS= -21.063

FREE MOTION
T= .01461 PHI= 135.359 PHDOT=-273.779 PSI= 42.612 PSIDOT=-123.677 PHITOT = 80.359
T= .01462 PHI= 135.205 PHDOT=-263.367 PSI= 42.541 PSIDOT=-123.677 PHITOT = 80.205

VP= -7.263 VS= -20.128

FREE MOTION
T= .01462 PHI= 135.205 PHDOT=-263.367 PSI= 42.541 PSIDOT=-123.677 PHITOT = 80.205
T= .01463 PHI= 135.057 PHDOT=-252.955 PSI= 42.470 PSIDOT=-123.677 PHITOT = 80.057

VP= -7.276 VS= -19.192

FREE MOTION
T= .01463 PHI= 135.057 PHDOT=-252.955 PSI= 42.470 PSIDOT=-123.677 PHITOT = 80.057
T= .01464 PHI= 134.915 PHDOT=-242.543 PSI= 42.399 PSIDOT=-123.677 PHITOT = 79.915
T= .01465 PHI= 134.779 PHDOT=-232.131 PSI= 42.329 PSIDOT=-123.677 PHITOT = 79.779
T= .01466 PHI= 134.649 PHDOT=-221.720 PSI= 42.258 PSIDOT=-123.677 PHITOT = 79.649
T= .01467 PHI= 134.525 PHDOT=-211.308 PSI= 42.187 PSIDOT=-123.677 PHITOT = 79.525
T= .01468 PHI= 134.407 PHDOT=-200.896 PSI= 42.116 PSIDOT=-123.677 PHITOT = 79.407
T= .01469 PHI= 134.295 PHDOT=-190.484 PSI= 42.045 PSIDOT=-123.677 PHITOT = 79.295
T= .01470 PHI= 134.189 PHDOT=-180.073 PSI= 41.974 PSIDOT=-123.677 PHITOT = 79.189
T= .01471 PHI= 134.089 PHDOT=-169.661 PSI= 41.903 PSIDOT=-123.677 PHITOT = 79.089
T= .01472 PHI= 133.994 PHDOT=-159.249 PSI= 41.833 PSIDOT=-123.677 PHITOT = 78.994
T= .01473 PHI= 133.906 PHDOT=-148.837 PSI= 41.762 PSIDOT=-123.677 PHITOT = 78.906
T= .01474 PHI= 133.824 PHDOT=-138.426 PSI= 41.691 PSIDOT=-123.677 PHITOT = 78.824
T= .01475 PHI= 133.748 PHDOT=-128.014 PSI= 41.620 PSIDOT=-123.677 PHITOT = 78.748
T= .01476 PHI= 133.677 PHDOT=-117.602 PSI= 41.549 PSIDOT=-123.677 PHITOT = 78.677
T= .01477 PHI= 133.613 PHDOT=-107.190 PSI= 41.478 PSIDOT=-123.677 PHITOT = 78.613
T= .01478 PHI= 133.554 PHDOT= -96.779 PSI= 41.407 PSIDOT=-123.677 PHITOT = 78.554
T= .01479 PHI= 133.502 PHDOT= -86.367 PSI= 41.337 PSIDOT=-123.677 PHITOT = 78.502
T= .01480 PHI= 133.455 PHDOT= -75.955 PSI= 41.266 PSIDOT=-123.677 PHITOT = 78.455
T= .01481 PHI= 133.415 PHDOT= -65.543 PSI= 41.195 PSIDOT=-123.677 PHITOT = 78.415
T= .01482 PHI= 133.380 PHDOT= -55.131 PSI= 41.124 PSIDOT=-123.677 PHITOT = 78.380
T= .01483 PHI= 133.352 PHDOT= -44.720 PSI= 41.053 PSIDOT=-123.677 PHITOT = 78.352
T= .01484 PHI= 133.329 PHDOT= -34.308 PSI= 40.982 PSIDOT=-123.677 PHITOT = 78.329
T= .01485 PHI= 133.312 PHDOT= -23.896 PSI= 40.911 PSIDOT=-123.677 PHITOT = 78.312
T= .01486 PHI= 133.302 PHDOT= -13.484 PSI= 40.840 PSIDOT=-123.677 PHITOT = 78.302
T= .01487 PHI= 133.297 PHDOT= -3.073 PSI= 40.770 PSIDOT=-123.677 PHITOT = 78.297
T= .01488 PHI= 133.298 PHDOT= 7.339 PSI= 40.699 PSIDOT=-123.677 PHITOT = 78.298

#46

```
          T=  .05256   PHI= 202.414   PHIDOT= 152.345   G=  -.0154   GDOT=  29.371   PSID= 306.270   PSIDOT=-208.292   PHITOT = 267.414
          T=  .05266   PHI= 203.282   PHIDOT= 150.537   G=  -.0125   GDOT=  30.286   PSID= 305.061   PSIDOT=-215.431   PHITOT = 268.282
          T=  .05276   PHI= 204.137   PHIDOT= 147.725   G=  -.0096   GDOT=  31.096   PSID= 303.802   PSIDOT=-224.029   PHITOT = 269.137
          T=  .05286   PHI= 204.973   PHIDOT= 144.015   G=  -.0062   GDOT=  31.802   PSID= 302.495   PSIDOT=-232.072   PHITOT = 269.973
          T=  .05296   PHI= 205.786   PHIDOT= 139.514   G=  -.0030   GDOT=  32.407   PSID= 301.144   PSIDOT=-239.549   PHITOT = 270.786
          T=  .05306   PHI= 206.571   PHIDOT= 134.339   G=   .0002   GDOT=  32.912   PSID= 299.751   PSIDOT=-246.454   PHITOT = 271.571

          FREE MOTION
          T=  .05306   PHI= 126.571   PHIDOT= 134.339   PSI=  49.088   PSIDOT=-246.454   PHITOT = 271.571
          T=  .05307   PHI= 126.651   PHIDOT= 144.751   PSI=  48.947   PSIDOT=-246.454   PHITOT = 271.651
          T=  .05308   PHI= 126.737   PHIDOT= 155.163   PSI=  48.806   PSIDOT=-246.454   PHITOT = 271.737
          T=  .05309   PHI= 126.829   PHIDOT= 165.574   PSI=  48.665   PSIDOT=-246.454   PHITOT = 271.829
          T=  .05310   PHI= 126.927   PHIDOT= 175.986   PSI=  48.524   PSIDOT=-246.454   PHITOT = 271.927
          T=  .05311   PHI= 127.030   PHIDOT= 186.398   PSI=  48.382   PSIDOT=-246.454   PHITOT = 272.030
          T=  .05312   PHI= 127.140   PHIDOT= 196.810   PSI=  48.241   PSIDOT=-246.454   PHITOT = 272.140
          T=  .05313   PHI= 127.256   PHIDOT= 207.221   PSI=  48.100   PSIDOT=-246.454   PHITOT = 272.256
          T=  .05314   PHI= 127.378   PHIDOT= 217.633   PSI=  47.959   PSIDOT=-246.454   PHITOT = 272.378
          T=  .05315   PHI= 127.505   PHIDOT= 228.045   PSI=  47.818   PSIDOT=-246.454   PHITOT = 272.505
          T=  .05316   PHI= 127.639   PHIDOT= 238.457   PSI=  47.676   PSIDOT=-246.454   PHITOT = 272.639
          T=  .05317   PHI= 127.779   PHIDOT= 248.868   PSI=  47.535   PSIDOT=-246.454   PHITOT = 272.779
          T=  .05318   PHI= 127.924   PHIDOT= 259.280   PSI=  47.394   PSIDOT=-246.454   PHITOT = 272.924
          T=  .05319   PHI= 128.076   PHIDOT= 269.692   PSI=  47.253   PSIDOT=-246.454   PHITOT = 273.076
          T=  .05320   PHI= 128.233   PHIDOT= 280.104   PSI=  47.112   PSIDOT=-246.454   PHITOT = 273.233
          T=  .05321   PHI= 128.397   PHIDOT= 290.515   PSI=  46.970   PSIDOT=-246.454   PHITOT = 273.397
          T=  .05322   PHI= 128.566   PHIDOT= 300.927   PSI=  46.829   PSIDOT=-246.454   PHITOT = 273.566
          T=  .05323   PHI= 128.741   PHIDOT= 311.339   PSI=  46.688   PSIDOT=-246.454   PHITOT = 273.741
          T=  .05324   PHI= 128.923   PHIDOT= 321.751   PSI=  46.547   PSIDOT=-246.454   PHITOT = 273.923
          T=  .05325   PHI= 129.110   PHIDOT= 332.163   PSI=  46.406   PSIDOT=-246.454   PHITOT = 274.110
          T=  .05326   PHI= 129.303   PHIDOT= 342.574   PSI=  46.266   PSIDOT=-246.454   PHITOT = 274.303
          T=  .05327   PHI= 129.503   PHIDOT= 352.986   PSI=  46.123   PSIDOT=-246.454   PHITOT = 274.503
          T=  .05328   PHI= 129.708   PHIDOT= 363.398   PSI=  45.982   PSIDOT=-246.454   PHITOT = 274.708
          T=  .05329   PHI= 129.919   PHIDOT= 373.810   PSI=  45.841   PSIDOT=-246.454   PHITOT = 274.919
          T=  .05330   PHI= 130.136   PHIDOT= 384.221   PSI=  45.699   PSIDOT=-246.454   PHITOT = 275.136
          T=  .05331   PHI= 130.359   PHIDOT= 394.633   PSI=  45.558   PSIDOT=-246.454   PHITOT = 275.359
          T=  .05332   PHI= 130.588   PHIDOT= 405.045   PSI=  45.417   PSIDOT=-246.454   PHITOT = 275.588
          T=  .05333   PHI= 130.824   PHIDOT= 415.457   PSI=  45.276   PSIDOT=-246.454   PHITOT = 275.824
          T=  .05334   PHI= 131.065   PHIDOT= 425.868   PSI=  45.135   PSIDOT=-246.454   PHITOT = 276.065
          T=  .05335   PHI= 131.312   PHIDOT= 436.280   PSI=  44.993   PSIDOT=-246.454   PHITOT = 276.312
          T=  .05336   PHI= 131.565   PHIDOT= 446.692   PSI=  44.852   PSIDOT=-246.454   PHITOT = 276.565
          T=  .05337   PHI= 131.823   PHIDOT= 457.104   PSI=  44.711   PSIDOT=-246.454   PHITOT = 276.823
          T=  .05338   PHI= 132.088   PHIDOT= 467.515   PSI=  44.570   PSIDOT=-246.454   PHITOT = 277.088
          T=  .05339   PHI= 132.359   PHIDOT= 477.927   PSI=  44.429   PSIDOT=-246.454   PHITOT = 277.359
          T=  .05340   PHI= 132.636   PHIDOT= 488.339   PSI=  44.287   PSIDOT=-246.454   PHITOT = 277.636
          T=  .05341   PHI= 132.919   PHIDOT= 498.751   PSI=  44.146   PSIDOT=-246.454   PHITOT = 277.919
          T=  .05342   PHI= 133.208   PHIDOT= 509.163   PSI=  44.005   PSIDOT=-246.454   PHITOT = 278.208
          T=  .05343   PHI= 133.502   PHIDOT= 519.574   PSI=  43.864   PSIDOT=-246.454   PHITOT = 278.502
          T=  .05344   PHI= 133.803   PHIDOT= 529.986   PSI=  43.723   PSIDOT=-246.454   PHITOT = 278.803
          T=  .05345   PHI= 134.110   PHIDOT= 540.398   PSI=  43.581   PSIDOT=-246.454   PHITOT = 279.110
          T=  .05346   PHI= 134.422   PHIDOT= 550.810   PSI=  43.440   PSIDOT=-246.454   PHITOT = 279.422
          T=  .05347   PHI= 134.741   PHIDOT= 561.221   PSI=  43.299   PSIDOT=-246.454   PHITOT = 279.741
          T=  .05348   PHI= 135.065   PHIDOT= 571.633   PSI=  43.158   PSIDOT=-246.454   PHITOT = 280.065
          T=  .05349   PHI= 135.396   PHIDOT= 582.045   PSI=  43.017   PSIDOT=-246.454   PHITOT = 280.396
          T=  .05350   PHI= 135.732   PHIDOT= 592.457   PSI=  42.875   PSIDOT=-246.456   PHITOT = 280.732
VP= -14.409   VS=  46.458

          IMPACT                Cycle No. 8

                       PHI= 135.732   DPHIF=-286.525   PSI=  42.875   DPSIF=-124.023   PHITOT= 280.732
VP=  -7.251   VS= -22.468

          FREE MOTION
          T=  .05350   PHI= 135.732   PHIDOT=-286.525   PSI=  42.875   PSIDOT=-124.023   PHITOT = 280.732
          T=  .05351   PHI= 135.571   PHIDOT=-276.113   PSI=  42.804   PSIDOT=-124.023   PHITOT = 280.571
VP=  -7.246   VS= -21.483
```

End of Cycle No. 7

```
        FREE MOTION
        T=  .05351   PHI= 135.571   PHIDOT=-276.113   PSI=  42.804   PSIDOT=-124.023   PHITOT = 280.571
        T=  .05352   PHI= 135.416   PHIDOT=-265.701   PSI=  42.733   PSIDOT=-124.023   PHITOT = 280.416
   VP=  -7.280   VS= -20.517

        FREE MOTION
        T=  .05352   PHI= 135.416   PHIDOT=-265.701   PSI=  42.733   PSIDOT=-124.023   PHITOT = 280.416
        T=  .05353   PHI= 135.267   PHIDOT=-255.289   PSI=  42.662   PSIDOT=-124.023   PHITOT = 280.267
   VP=  -7.293   VS= -19.570

        FREE MOTION
        T=  .05353   PHI= 135.267   PHIDOT=-255.289   PSI=  42.662   PSIDOT=-124.023   PHITOT = 280.267
        T=  .05354   PHI= 135.123   PHIDOT=-244.878   PSI=  42.591   PSIDOT=-124.023   PHITOT = 280.123
        T=  .05355   PHI= 134.986   PHIDOT=-234.466   PSI=  42.520   PSIDOT=-124.023   PHITOT = 279.986
        T=  .05356   PHI= 134.855   PHIDOT=-224.054   PSI=  42.449   PSIDOT=-124.023   PHITOT = 279.855
        T=  .05357   PHI= 134.729   PHIDOT=-213.642   PSI=  42.378   PSIDOT=-124.023   PHITOT = 279.729
        T=  .05358   PHI= 134.610   PHIDOT=-203.231   PSI=  42.307   PSIDOT=-124.023   PHITOT = 279.610
        T=  .05359   PHI= 134.496   PHIDOT=-192.819   PSI=  42.236   PSIDOT=-124.023   PHITOT = 279.496
        T=  .05360   PHI= 134.389   PHIDOT=-182.407   PSI=  42.165   PSIDOT=-124.023   PHITOT = 279.389
        T=  .05361   PHI= 134.287   PHIDOT=-171.995   PSI=  42.094   PSIDOT=-124.023   PHITOT = 279.287
        T=  .05362   PHI= 134.192   PHIDOT=-161.583   PSI=  42.023   PSIDOT=-124.023   PHITOT = 279.192
        T=  .05363   PHI= 134.102   PHIDOT=-151.172   PSI=  41.952   PSIDOT=-124.023   PHITOT = 279.102
        T=  .05364   PHI= 134.019   PHIDOT=-140.760   PSI=  41.880   PSIDOT=-124.023   PHITOT = 279.019
        T=  .05365   PHI= 133.941   PHIDOT=-130.348   PSI=  41.809   PSIDOT=-124.023   PHITOT = 278.941
        T=  .05366   PHI= 133.869   PHIDOT=-119.936   PSI=  41.738   PSIDOT=-124.023   PHITOT = 278.869
        T=  .05367   PHI= 133.803   PHIDOT=-109.525   PSI=  41.667   PSIDOT=-124.023   PHITOT = 278.803
        T=  .05368   PHI= 133.744   PHIDOT= -99.113   PSI=  41.596   PSIDOT=-124.023   PHITOT = 278.744
        T=  .05369   PHI= 133.690   PHIDOT= -88.701   PSI=  41.525   PSIDOT=-124.023   PHITOT = 278.690
        T=  .05370   PHI= 133.642   PHIDOT= -78.289   PSI=  41.454   PSIDOT=-124.023   PHITOT = 278.642
        T=  .05371   PHI= 133.600   PHIDOT= -67.878   PSI=  41.383   PSIDOT=-124.023   PHITOT = 278.600
        T=  .05372   PHI= 133.564   PHIDOT= -57.466   PSI=  41.312   PSIDOT=-124.023   PHITOT = 278.564
        T=  .05373   PHI= 133.534   PHIDOT= -47.054   PSI=  41.241   PSIDOT=-124.023   PHITOT = 278.534
        T=  .05374   PHI= 133.510   PHIDOT= -36.642   PSI=  41.170   PSIDOT=-124.023   PHITOT = 278.510
        T=  .05375   PHI= 133.492   PHIDOT= -26.231   PSI=  41.099   PSIDOT=-124.023   PHITOT = 278.492
        T=  .05376   PHI= 133.480   PHIDOT= -15.819   PSI=  41.028   PSIDOT=-124.023   PHITOT = 278.480
        T=  .05377   PHI= 133.474   PHIDOT=  -5.407   PSI=  40.957   PSIDOT=-124.023   PHITOT = 278.474
        T=  .05378   PHI= 133.474   PHIDOT=   5.005   PSI=  40.886   PSIDOT=-124.023   PHITOT = 278.474
        T=  .05379   PHI= 133.480   PHIDOT=  15.417   PSI=  40.815   PSIDOT=-124.023   PHITOT = 278.480
        T=  .05380   PHI= 133.492   PHIDOT=  25.828   PSI=  40.744   PSIDOT=-124.023   PHITOT = 278.492
        T=  .05381   PHI= 133.509   PHIDOT=  36.240   PSI=  40.672   PSIDOT=-124.023   PHITOT = 278.509
        T=  .05382   PHI= 133.533   PHIDOT=  46.652   PSI=  40.601   PSIDOT=-124.023   PHITOT = 278.533
        T=  .05383   PHI= 133.563   PHIDOT=  57.064   PSI=  40.530   PSIDOT=-124.023   PHITOT = 278.563
   VP=  -7.222   VS=   4.015

        IMPACT

                     PHI= 133.563   DPHIF=-119.929   PSI=  40.530   DPSIF= -96.656   PHITOT= 278.563
   VP=  -5.628   VS=  -8.437

        FREE MOTION
        T=  .05383   PHI= 133.563   PHIDOT=-119.929   PSI=  40.530   PSIDOT= -96.656   PHITOT = 278.563
        T=  .05384   PHI= 133.497   PHIDOT=-109.517   PSI=  40.475   PSIDOT= -96.656   PHITOT = 278.497
   VP=  -5.630   VS=  -7.679

        FREE MOTION
        T=  .05384   PHI= 133.497   PHIDOT=-109.517   PSI=  40.475   PSIDOT= -96.656   PHITOT = 278.497
        T=  .05385   PHI= 133.437   PHIDOT= -99.105   PSI=  40.420   PSIDOT= -96.656   PHITOT = 278.437
   VP=  -5.630   VS=  -6.927

        FREE MOTION
        T=  .05385   PHI= 133.437   PHIDOT= -99.105   PSI=  40.420   PSIDOT= -96.656   PHITOT = 278.437
        T=  .05386   PHI= 133.384   PHIDOT= -88.694   PSI=  40.364   PSIDOT= -96.656   PHITOT = 278.384
   VP=  -5.630   VS=  -6.182
```

FREE MOTION

T= .05386 PHI= 133.384 PHIDOT= -88.694 PSI= 40.364 PSIDOT= -96.656 PHITOT = 278.384

T= .05387 PHI= 133.336 PHIDOT= -78.282 PSI= 40.309 PSIDOT= -96.656 PHITOT = 278.336

VP= -5.629 VS= -5.443

IMPACT

PHI= 133.336 DPHIF= -81.242 PSI= 40.309 DPSIF= -96.193 PHITOT= 278.336

VP= -5.602 VS= -5.649

COUPLED MOTION

T= .05387	PHI= 133.336	PHIDOT= -81.242	G= -.0518	GDOT= -16.872	PSI= 40.309	PSIDOT= -96.901	PHITOT = 278.336				
T= .05397	PHI= 132.945	PHIDOT= -54.986	G= -.0532	GDOT= -11.329	PSI= 39.887	PSIDOT= -64.357	PHITOT = 277.945				
T= .05407	PHI= 132.709	PHIDOT= -27.221	G= -.0541	GDOT= -5.581	PSI= 39.612	PSIDOT= -31.493	PHITOT = 277.709				
T= .05409	PHI= 132.675	PHIDOT= -20.127	G= -.0542	GDOT= -4.124	PSI= 39.573	PSIDOT= -23.247	PHITOT = 277.675				
T= .05412	PHI= 132.651	PHIDOT= -12.997	G= -.0543	GDOT= -2.662	PSI= 39.546	PSIDOT= -14.994	PHITOT = 277.651				
T= .05413	PHI= 132.643	PHIDOT= -9.429	G= -.0543	GDOT= -1.929	PSI= 39.537	PSIDOT= -10.866	PHITOT = 277.643				
T= .05414	PHI= 132.638	PHIDOT= -5.861	G= -.0543	GDOT= -1.196	PSI= 39.530	PSIDOT= -6.737	PHITOT = 277.638				
T= .05415	PHI= 132.636	PHIDOT= -4.053	G= -.0543	GDOT= -.830	PSI= 39.528	PSIDOT= -4.672	PHITOT = 277.636				
T= .05416	PHI= 132.635	PHIDOT= -2.262	G= -.0543	GDOT= -.463	PSI= 39.527	PSIDOT= -2.607	PHITOT = 277.635				
T= .05416	PHI= 132.634	PHIDOT= -1.344	G= -.0543	GDOT= -.280	PSI= 39.526	PSIDOT= -1.575	PHITOT = 277.634				
T= .05416	PHI= 132.634	PHIDOT= -.471	G= -.0543	GDOT= -.096	PSI= 39.526	PSIDOT= -.542	PHITOT = 277.634				
T= .05416	PHI= 132.634	PHIDOT= -.247	G= -.0543	GDOT= -.050	PSI= 39.526	PSIDOT= -.284	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= -.023	G= -.0543	GDOT= -.005	PSI= 39.526	PSIDOT= -.026	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .023	G= -.0543	GDOT= .006	PSI= 39.526	PSIDOT= .032	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .048	G= -.0543	GDOT= .010	PSI= 39.526	PSIDOT= .055	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .067	G= -.0543	GDOT= .014	PSI= 39.526	PSIDOT= .078	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .087	G= -.0543	GDOT= .018	PSI= 39.526	PSIDOT= .101	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .127	G= -.0543	GDOT= .026	PSI= 39.526	PSIDOT= .146	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .166	G= -.0543	GDOT= .034	PSI= 39.526	PSIDOT= .192	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .206	G= -.0543	GDOT= .042	PSI= 39.526	PSIDOT= .238	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .244	G= -.0543	GDOT= .050	PSI= 39.526	PSIDOT= .283	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .325	G= -.0543	GDOT= .067	PSI= 39.526	PSIDOT= .374	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .404	G= -.0543	GDOT= .083	PSI= 39.526	PSIDOT= .466	PHITOT = 277.634				
T= .05417	PHI= 132.634	PHIDOT= .483	G= -.0543	GDOT= .099	PSI= 39.526	PSIDOT= .557	PHITOT = 277.634				
T= .05418	PHI= 132.634	PHIDOT= .562	G= -.0543	GDOT= .115	PSI= 39.526	PSIDOT= .648	PHITOT = 277.634				
T= .05418	PHI= 132.634	PHIDOT= .721	G= -.0543	GDOT= .148	PSI= 39.527	PSIDOT= .831	PHITOT = 277.634				
T= .05418	PHI= 132.635	PHIDOT= .879	G= -.0543	GDOT= .180	PSI= 39.527	PSIDOT= 1.014	PHITOT = 277.635				
T= .05419	PHI= 132.635	PHIDOT= 1.194	G= -.0543	GDOT= .245	PSI= 39.527	PSIDOT= 1.379	PHITOT = 277.635				
T= .05419	PHI= 132.635	PHIDOT= 1.513	G= -.0543	GDOT= .310	PSI= 39.527	PSIDOT= 1.744	PHITOT = 277.635				
T= .05421	PHI= 132.637	PHIDOT= 2.144	G= -.0543	GDOT= .439	PSI= 39.529	PSIDOT= 2.474	PHITOT = 277.637				
T= .05422	PHI= 132.638	PHIDOT= 2.779	G= -.0543	GDOT= .569	PSI= 39.531	PSIDOT= 3.204	PHITOT = 277.638				
T= .05424	PHI= 132.643	PHIDOT= 4.045	G= -.0543	GDOT= .828	PSI= 39.537	PSIDOT= 4.665	PHITOT = 277.643				
T= .05427	PHI= 132.650	PHIDOT= 5.310	G= -.0543	GDOT= 1.087	PSI= 39.545	PSIDOT= 6.125	PHITOT = 277.650				
T= .05432	PHI= 132.669	PHIDOT= 7.834	G= -.0542	GDOT= 1.605	PSI= 39.566	PSIDOT= 9.045	PHITOT = 277.669				
T= .05437	PHI= 132.695	PHIDOT= 10.349	G= -.0541	GDOT= 2.121	PSI= 39.596	PSIDOT= 11.964	PHITOT = 277.695				
T= .05442	PHI= 132.728	PHIDOT= 12.859	G= -.0540	GDOT= 2.636	PSI= 39.635	PSIDOT= 14.881	PHITOT = 277.728				
T= .05447	PHI= 132.769	PHIDOT= 15.334	G= -.0538	GDOT= 3.148	PSI= 39.682	PSIDOT= 17.796	PHITOT = 277.769				
T= .05457	PHI= 132.871	PHIDOT= 20.252	G= -.0535	GDOT= 4.166	PSI= 39.800	PSIDOT= 23.618	PHITOT = 277.871				
T= .05467	PHI= 133.000	PHIDOT= 25.073	G= -.0530	GDOT= 5.172	PSI= 39.952	PSIDOT= 29.426	PHITOT = 278.000				
T= .05477	PHI= 133.158	PHIDOT= 29.781	G= -.0524	GDOT= 6.163	PSI= 40.138	PSIDOT= 35.219	PHITOT = 278.158				
T= .05487	PHI= 133.341	PHIDOT= 34.359	G= -.0518	GDOT= 7.136	PSI= 40.356	PSIDOT= 40.993	PHITOT = 278.341				
T= .05497	PHI= 133.551	PHIDOT= 38.795	G= -.0510	GDOT= 8.091	PSI= 40.607	PSIDOT= 46.746	PHITOT = 278.551				
T= .05507	PHI= 133.786	PHIDOT= 43.076	G= -.0502	GDOT= 9.026	PSI= 40.892	PSIDOT= 52.476	PHITOT = 278.786				
T= .05517	PHI= 134.044	PHIDOT= 47.193	G= -.0492	GDOT= 9.938	PSI= 41.209	PSIDOT= 58.181	PHITOT = 279.044				
T= .05527	PHI= 134.326	PHIDOT= 51.144	G= -.0482	GDOT= 10.828	PSI= 41.558	PSIDOT= 63.859	PHITOT = 279.326				
T= .05537	PHI= 134.630	PHIDOT= 54.921	G= -.0470	GDOT= 11.694	PSI= 41.940	PSIDOT= 69.510	PHITOT = 279.630				
T= .05547	PHI= 134.955	PHIDOT= 58.532	G= -.0458	GDOT= 12.537	PSI= 42.355	PSIDOT= 75.132	PHITOT = 279.955				
T= .05557	PHI= 135.301	PHIDOT= 61.971	G= -.0445	GDOT= 13.356	PSI= 42.801	PSIDOT= 80.725	PHITOT = 280.301				
T= .05567	PHI= 135.665	PHIDOT= 65.245	G= -.0432	GDOT= 14.151	PSI= 43.280	PSIDOT= 86.289	PHITOT = 280.665				
T= .05577	PHI= 136.048	PHIDOT= 68.359	G= -.0417	GDOT= 14.923	PSI= 43.790	PSIDOT= 91.823	PHITOT = 281.048				
T= .05587	PHI= 136.448	PHIDOT= 71.319	G= -.0402	GDOT= 15.672	PSI= 44.332	PSIDOT= 97.330	PHITOT = 281.448				
T= .05597	PHI= 136.865	PHIDOT= 74.133	G= -.0386	GDOT= 16.399	PSI= 44.905	PSIDOT= 102.809	PHITOT = 281.865				
T= .05607	PHI= 137.297	PHIDOT= 76.804	G= -.0369	GDOT= 17.105	PSI= 45.510	PSIDOT= 108.261	PHITOT = 282.297				
T= .05617	PHI= 137.745	PHIDOT= 79.354	G= -.0352	GDOT= 17.789	PSI= 46.146	PSIDOT= 113.688	PHITOT = 282.745				

T= .05627 PHI= 178.206 PHIDOT= 81.787 G= -.0331 GDOT= 18.454 PSID= 46.813 PSIDOT= 119.092 PHITOT = 283.206

T= .05637 PHI= 178.692 PHIDOT= 84.098 G= -.0315 GDOT= 19.099 PSID= 47.510 PSIDOT= 124.473 PHITOT = 283.692

T= .05647 PHI= 179.170 PHIDOT= 86.319 G= -.0295 GDOT= 19.726 PSID= 48.239 PSIDOT= 129.835 PHITOT = 284.170

T= .05657 PHI= 179.671 PHIDOT= 88.434 G= -.0275 GDOT= 20.335 PSID= 48.998 PSIDOT= 135.178 PHITOT = 284.671

T= .05667 PHI= 180.183 PHIDOT= 90.471 G= -.0255 GDOT= 20.927 PSID= 49.788 PSIDOT= 140.506 PHITOT = 285.183

T= .05677 PHI= 180.707 PHIDOT= 92.432 G= -.0233 GDOT= 21.504 PSID= 50.604 PSIDOT= 145.819 PHITOT = 285.707

T= .05687 PHI= 181.242 PHIDOT= 94.326 G= -.0212 GDOT= 22.066 PSID= 51.450 PSIDOT= 151.121 PHITOT = 286.242

T= .05697 PHI= 181.788 PHIDOT= 96.158 G= -.0189 GDOT= 22.610 PSID= 52.340 PSIDOT= 156.414 PHITOT = 286.788

T= .05707 PHI= 182.344 PHIDOT= 97.938 G= -.0166 GDOT= 23.141 PSID= 53.251 PSIDOT= 161.700 PHITOT = 287.344

T= .05717 PHI= 182.910 PHIDOT= 99.672 G= -.0143 GDOT= 23.658 PSID= 54.193 PSIDOT= 166.980 PHITOT = 287.910

T= .05727 PHI= 183.486 PHIDOT= 101.364 G= -.0119 GDOT= 24.161 PSID= 55.165 PSIDOT= 172.254 PHITOT = 288.486

T= .05737 PHI= 184.072 PHIDOT= 103.022 G= -.0095 GDOT= 24.651 PSID= 56.167 PSIDOT= 177.526 PHITOT = 289.072

T= .05747 PHI= 184.667 PHIDOT= 104.650 G= -.0070 GDOT= 25.127 PSID= 57.199 PSIDOT= 182.815 PHITOT = 289.667

T= .05757 PHI= 185.271 PHIDOT= 106.254 G= -.0044 GDOT= 25.590 PSID= 58.262 PSIDOT= 188.098 PHITOT = 290.271

T= .05767 PHI= 185.884 PHIDOT= 107.834 G= -.0019 GDOT= 26.040 PSID= 59.356 PSIDOT= 193.387 PHITOT = 290.884

T= .05777 PHI= 186.506 PHIDOT= 109.402 G= .0008 GDOT= 26.477 PSID= 60.478 PSIDOT= 198.683 PHITOT = 291.506

FREE MOTION

T= .05777 PHI= 186.506 PHDOT= 109.402 PSI= 311.141 PSIDOT= 198.683 PHITOT = 291.506

T= .05778 PHI= 186.572 PHDOT= 119.814 PSI= 311.255 PSIDOT= 198.683 PHITOT = 291.572

T= .05779 PHI= 186.644 PHDOT= 130.226 PSI= 311.368 PSIDOT= 198.683 PHITOT = 291.644

T= .05780 PHI= 186.721 PHDOT= 140.638 PSI= 311.482 PSIDOT= 198.683 PHITOT = 291.721

T= .05781 PHI= 186.805 PHDOT= 151.049 PSI= 311.596 PSIDOT= 198.683 PHITOT = 291.805

T= .05782 PHI= 186.894 PHDOT= 161.461 PSI= 311.710 PSIDOT= 198.683 PHITOT = 291.894

T= .05783 PHI= 186.990 PHDOT= 171.873 PSI= 311.824 PSIDOT= 198.683 PHITOT = 291.990

T= .05784 PHI= 187.091 PHDOT= 182.285 PSI= 311.938 PSIDOT= 198.683 PHITOT = 292.091

T= .05785 PHI= 187.199 PHDOT= 192.696 PSI= 312.051 PSIDOT= 198.683 PHITOT = 292.199

T= .05786 PHI= 187.312 PHDOT= 203.108 PSI= 312.165 PSIDOT= 198.683 PHITOT = 292.312

T= .05787 PHI= 187.432 PHDOT= 213.520 PSI= 312.279 PSIDOT= 198.683 PHITOT = 292.432

T= .05788 PHI= 187.557 PHDOT= 223.932 PSI= 312.393 PSIDOT= 198.683 PHITOT = 292.557

T= .05789 PHI= 187.688 PHDOT= 234.343 PSI= 312.507 PSIDOT= 198.683 PHITOT = 292.688

T= .05790 PHI= 187.825 PHDOT= 244.755 PSI= 312.621 PSIDOT= 198.683 PHITOT = 292.825

T= .05791 PHI= 187.969 PHDOT= 255.167 PSI= 312.734 PSIDOT= 198.683 PHITOT = 292.969

T= .05792 PHI= 188.118 PHDOT= 265.579 PSI= 312.848 PSIDOT= 198.683 PHITOT = 293.118

T= .05793 PHI= 188.273 PHDOT= 275.990 PSI= 312.962 PSIDOT= 198.683 PHITOT = 293.273

T= .05794 PHI= 188.434 PHDOT= 286.402 PSI= 313.076 PSIDOT= 198.683 PHITOT = 293.434

T= .05795 PHI= 188.601 PHDOT= 296.814 PSI= 313.190 PSIDOT= 198.683 PHITOT = 293.601

T= .05796 PHI= 188.774 PHDOT= 307.226 PSI= 313.304 PSIDOT= 198.683 PHITOT = 293.774

T= .05797 PHI= 188.953 PHDOT= 317.638 PSI= 313.417 PSIDOT= 198.683 PHITOT = 293.953

T= .05798 PHI= 189.138 PHDOT= 328.049 PSI= 313.531 PSIDOT= 198.683 PHITOT = 294.138

T= .05799 PHI= 189.329 PHDOT= 338.461 PSI= 313.645 PSIDOT= 198.683 PHITOT = 294.329

T= .05800 PHI= 189.526 PHDOT= 348.873 PSI= 313.759 PSIDOT= 198.683 PHITOT = 294.526

T= .05801 PHI= 189.729 PHDOT= 359.285 PSI= 313.873 PSIDOT= 198.683 PHITOT = 294.729

T= .05802 PHI= 189.938 PHDOT= 369.696 PSI= 313.987 PSIDOT= 198.683 PHITOT = 294.938

T= .05803 PHI= 190.153 PHDOT= 380.108 PSI= 314.101 PSIDOT= 198.683 PHITOT = 295.153

T= .05804 PHI= 190.373 PHDOT= 390.520 PSI= 314.214 PSIDOT= 198.683 PHITOT = 295.373

T= .05805 PHI= 190.600 PHDOT= 400.932 PSI= 314.328 PSIDOT= 198.683 PHITOT = 295.600

T= .05806 PHI= 190.833 PHDOT= 411.343 PSI= 314.442 PSIDOT= 198.683 PHITOT = 295.833

T= .05807 PHI= 191.071 PHDOT= 421.755 PSI= 314.556 PSIDOT= 198.683 PHITOT = 296.071

T= .05808 PHI= 191.316 PHDOT= 432.167 PSI= 314.670 PSIDOT= 198.683 PHITOT = 296.316

T= .05809 PHI= 191.567 PHDOT= 442.579 PSI= 314.784 PSIDOT= 198.683 PHITOT = 296.567

T= .05810 PHI= 191.823 PHDOT= 452.990 PSI= 314.897 PSIDOT= 198.683 PHITOT = 296.823

T= .05811 PHI= 192.086 PHDOT= 463.402 PSI= 315.011 PSIDOT= 198.683 PHITOT = 297.086

T= .05812 PHI= 192.354 PHDOT= 473.814 PSI= 315.125 PSIDOT= 198.683 PHITOT = 297.354

T= .05813 PHI= 192.629 PHDOT= 484.226 PSI= 315.239 PSIDOT= 198.683 PHITOT = 297.629

T= .05814 PHI= 192.909 PHDOT= 494.638 PSI= 315.353 PSIDOT= 198.683 PHITOT = 297.909

T= .05815 PHI= 193.196 PHDOT= 505.049 PSI= 315.467 PSIDOT= 198.683 PHITOT = 298.196

T= .05816 PHI= 193.488 PHDOT= 515.461 PSI= 315.580 PSIDOT= 198.683 PHITOT = 298.488

T= .05817 PHI= 193.786 PHDOT= 525.873 PSI= 315.694 PSIDOT= 198.683 PHITOT = 298.786

VD= -18.247 VS= 42.715

IMPACT

PHI= 193.786 DPHIF=-231.270 PSI= 315.694 DPSIF= 38.403 PHITOT= 298.786

VP= -3.535 VS= -18.785

FREE MOTION

T= .05817 PHI= 193.746 PHDOT=-231.270 PSI= 315.694 PSIDOT= 38.403 PHITOT = 298.786
T= .05818 PHI= 193.657 PHDOT=-220.859 PSI= 315.716 PSIDOT= 38.403 PHITOT = 298.657
T= .05819 PHI= 193.573 PHDOT=-210.447 PSI= 315.738 PSIDOT= 38.403 PHITOT = 298.533
T= .05820 PHI= 193.496 PHDOT=-200.035 PSI= 315.760 PSIDOT= 38.403 PHITOT = 298.416
T= .05821 PHI= 193.394 PHDOT=-189.623 PSI= 315.782 PSIDOT= 38.403 PHITOT = 298.304
T= .05822 PHI= 193.198 PHDOT=-179.211 PSI= 315.804 PSIDOT= 38.403 PHITOT = 298.198
T= .05823 PHI= 193.099 PHDOT=-168.800 PSI= 315.826 PSIDOT= 38.403 PHITOT = 298.099
T= .05824 PHI= 193.005 PHDOT=-158.388 PSI= 315.848 PSIDOT= 38.403 PHITOT = 298.005
T= .05825 PHI= 192.917 PHDOT=-147.976 PSI= 315.870 PSIDOT= 38.403 PHITOT = 297.917
T= .05826 PHI= 192.835 PHDOT=-137.564 PSI= 315.892 PSIDOT= 38.403 PHITOT = 297.835
T= .05827 PHI= 192.759 PHDOT=-127.153 PSI= 315.914 PSIDOT= 38.403 PHITOT = 297.759
T= .05828 PHI= 192.690 PHDOT=-116.741 PSI= 315.936 PSIDOT= 38.403 PHITOT = 297.690
T= .05829 PHI= 192.626 PHDOT=-106.329 PSI= 315.958 PSIDOT= 38.403 PHITOT = 297.626
T= .05830 PHI= 192.568 PHDOT= -95.917 PSI= 315.980 PSIDOT= 38.403 PHITOT = 297.568
T= .05831 PHI= 192.516 PHDOT= -85.506 PSI= 316.002 PSIDOT= 38.403 PHITOT = 297.516
T= .05832 PHI= 192.470 PHDOT= -75.094 PSI= 316.024 PSIDOT= 38.403 PHITOT = 297.470
T= .05833 PHI= 192.430 PHDOT= -64.682 PSI= 316.046 PSIDOT= 38.403 PHITOT = 297.430
T= .05834 PHI= 192.396 PHDOT= -54.270 PSI= 316.068 PSIDOT= 38.403 PHITOT = 297.396
T= .05835 PHI= 192.367 PHDOT= -43.859 PSI= 316.090 PSIDOT= 38.403 PHITOT = 297.367
T= .05836 PHI= 192.345 PHDOT= -33.447 PSI= 316.112 PSIDOT= 38.403 PHITOT = 297.345
T= .05837 PHI= 192.329 PHDOT= -23.035 PSI= 316.134 PSIDOT= 38.403 PHITOT = 297.329
T= .05838 PHI= 192.319 PHDOT= -12.623 PSI= 316.156 PSIDOT= 38.403 PHITOT = 297.319
T= .05839 PHI= 192.315 PHDOT= -2.211 PSI= 316.178 PSIDOT= 38.403 PHITOT = 297.315
T= .05840 PHI= 192.316 PHDOT= 8.200 PSI= 316.200 PSIDOT= 38.403 PHITOT = 297.316
T= .05941 PHI= 192.324 PHDOT= 18.612 PSI= 316.222 PSIDOT= 38.403 PHITOT = 297.324
T= .05842 PHI= 192.338 PHDOT= 29.024 PSI= 316.244 PSIDOT= 38.403 PHITOT = 297.338
T= .05843 PHI= 192.357 PHDOT= 39.436 PSI= 316.266 PSIDOT= 38.403 PHITOT = 297.357
T= .05844 PHI= 192.383 PHDOT= 49.847 PSI= 316.288 PSIDOT= 38.403 PHITOT = 297.383
T= .05845 PHI= 192.414 PHDOT= 60.259 PSI= 316.310 PSIDOT= 38.403 PHITOT = 297.414
T= .05846 PHI= 192.452 PHDOT= 70.671 PSI= 316.332 PSIDOT= 38.403 PHITOT = 297.452
T= .05847 PHI= 192.495 PHDOT= 81.083 PSI= 316.354 PSIDOT= 38.403 PHITOT = 297.495
T= .05848 PHI= 192.545 PHDOT= 91.494 PSI= 316.376 PSIDOT= 38.403 PHITOT = 297.545
T= .05849 PHI= 192.600 PHDOT= 101.906 PSI= 316.398 PSIDOT= 38.403 PHITOT = 297.600
T= .05850 PHI= 192.662 PHDOT= 112.318 PSI= 316.420 PSIDOT= 38.403 PHITOT = 297.662
T= .05851 PHI= 192.729 PHDOT= 122.730 PSI= 316.442 PSIDOT= 38.403 PHITOT = 297.729
T= .05852 PHI= 192.802 PHDOT= 133.141 PSI= 316.464 PSIDOT= 38.403 PHITOT = 297.802
T= .05853 PHI= 192.882 PHDOT= 143.553 PSI= 316.486 PSIDOT= 38.403 PHITOT = 297.882

VP= -3.567 VS= 11.342

IMPACT

PHI= 192.882 DPHIF= -43.916 PSI= 316.486 DPSIF= -2.773 PHITOT= 297.882

VP= .25A VS= -3.470

FREE MOTION

T= .05853 PHI= 192.882 PHDOT= -43.916 PSI= 316.486 PSIDOT= -2.773 PHITOT = 297.882
T= .05854 PHI= 192.859 PHDOT= -33.504 PSI= 316.485 PSIDOT= -2.773 PHITOT = 297.859

VP= .25A VS= -2.645

FREE MOTION

T= .05854 PHI= 192.859 PHDOT= -33.504 PSI= 316.485 PSIDOT= -2.773 PHITOT = 297.859
T= .05855 PHI= 192.843 PHDOT= -23.092 PSI= 316.483 PSIDOT= -2.773 PHITOT = 297.843

VP= .25A VS= -1.822

FREE MOTION

T= .05855 PHI= 192.843 PHDOT= -23.092 PSI= 316.483 PSIDOT= -2.773 PHITOT = 297.843
T= .05856 PHI= 192.833 PHDOT= -12.681 PSI= 316.482 PSIDOT= -2.773 PHITOT = 297.833

VP= .25A VS= -1.000

FREE MOTION

T= .05856 PHI= 192.833 PHDOT= -12.681 PSI= 316.482 PSIDOT= -2.773 PHITOT = 297.833
T= .05857 PHI= 192.829 PHDOT= -2.269 PSI= 316.480 PSIDOT= -2.773 PHITOT = 297.829

VP= .258 VS= -.179

FREE MOTION

T= .05857 PHI= 192.829 PHIDOT= -2.269 PSI= 316.480 PSIDOT= -2.773 PHITOT = 297.829

T= .05858 PHI= 192.830 PHIDOT= 8.143 PSI= 316.478 PSIDOT= -2.773 PHITOT = 297.830

VP= .258 VS= .662

IMPACT

PHI= 192.830 DPHIF= 3.302 PSI= 316.478 DPSIF= -3.838 PHITOT= 297.830

VP= .357 VS= .260

COUPLED MOTION

T=	.05858	PHI= 192.830	PHIDOT= 3.302	G=	-.0424	GDOT= .458	PSI= 316.467	PSIDOT= -2.803	PHITOT = 297.830	
T=	.05868	PHI= 192.894	PHIDOT= 19.023	G=	-.0423	GDOT= 2.641	PSI= 316.412	PSIDOT= -14.193	PHITOT = 297.894	
T=	.05878	PHI= 193.048	PHIDOT= 34.594	G=	-.0419	GDOT= 4.810	PSI= 316.261	PSIDOT= -29.557	PHITOT = 298.048	
T=	.05888	PHI= 193.289	PHIDOT= 49.567	G=	-.0413	GDOT= 6.951	PSI= 316.074	PSIDOT= -42.873	PHITOT = 298.289	
T=	.05898	PHI= 193.615	PHIDOT= 64.028	G=	-.0405	GDOT= 9.055	PSI= 315.790	PSIDOT= -54.116	PHITOT = 298.615	
T=	.05908	PHI= 194.021	PHIDOT= 77.704	G=	-.0395	GDOT= 11.109	PSI= 315.431	PSIDOT= -69.262	PHITOT = 299.021	
T=	.05918	PHI= 194.503	PHIDOT= 90.456	G=	-.0383	GDOT= 13.104	PSI= 314.997	PSIDOT= -82.281	PHITOT = 299.503	
T=	.05928	PHI= 195.056	PHIDOT= 102.163	G=	-.0369	GDOT= 15.032	PSI= 314.488	PSIDOT= -95.144	PHITOT = 300.056	
T=	.05938	PHI= 195.672	PHIDOT= 112.704	G=	-.0353	GDOT= 16.886	PSI= 313.907	PSIDOT=-107.818	PHITOT = 300.672	
T=	.05948	PHI= 196.345	PHIDOT= 122.002	G=	-.0335	GDOT= 18.663	PSI= 313.253	PSIDOT=-120.264	PHITOT = 301.345	
T=	.05958	PHI= 197.067	PHIDOT= 129.989	G=	-.0316	GDOT= 20.334	PSI= 312.529	PSIDOT=-132.451	PHITOT = 302.067	
T=	.05968	PHI= 197.832	PHIDOT= 136.629	G=	-.0295	GDOT= 21.922	PSI= 311.736	PSIDOT=-144.339	PHITOT = 302.832	
T=	.05978	PHI= 198.630	PHIDOT= 141.904	G=	-.0272	GDOT= 23.413	PSI= 310.876	PSIDOT=-155.891	PHITOT = 303.630	
T=	.05988	PHI= 199.455	PHIDOT= 145.831	G=	-.0248	GDOT= 24.804	PSI= 309.951	PSIDOT=-167.070	PHITOT = 304.455	
T=	.05998	PHI= 200.299	PHIDOT= 148.431	G=	-.0222	GDOT= 26.093	PSI= 308.962	PSIDOT=-177.840	PHITOT = 305.299	
T=	.06008	PHI= 201.154	PHIDOT= 149.755	G=	-.0196	GDOT= 27.277	PSI= 307.914	PSIDOT=-188.170	PHITOT = 306.154	
T=	.06018	PHI= 202.013	PHIDOT= 149.867	G=	-.0168	GDOT= 28.357	PSI= 306.807	PSIDOT=-198.028	PHITOT = 307.013	
T=	.06028	PHI= 202.869	PHIDOT= 148.844	G=	-.0139	GDOT= 29.333	PSI= 305.645	PSIDOT=-207.388	PHITOT = 307.869	
T=	.06038	PHI= 203.716	PHIDOT= 146.785	G=	-.0109	GDOT= 30.204	PSI= 304.431	PSIDOT=-216.229	PHITOT = 308.716	
T=	.06048	PHI= 204.549	PHIDOT= 143.772	G=	-.0079	GDOT= 30.971	PSI= 303.168	PSIDOT=-224.531	PHITOT = 309.549	
T=	.06058	PHI= 205.362	PHIDOT= 139.921	G=	-.0047	GDOT= 31.638	PSI= 301.860	PSIDOT=-232.285	PHITOT = 310.362	
T=	.06068	PHI= 206.151	PHIDOT= 135.334	G=	-.0015	GDOT= 32.205	PSI= 300.508	PSIDOT=-239.480	PHITOT = 311.151	
T=	.06078	PHI= 206.912	PHIDOT= 130.118	G=	.0017	GDOT= 32.675	PSI= 299.116	PSIDOT=-246.111	PHITOT = 311.912	

FREE MOTION

T=	.06078	PHI= 126.912	PHIDOT= 170.118	PSI=	48.453	PSIDOT=-246.111	PHITOT = 311.912	
T=	.06079	PHI= 126.989	PHIDOT= 160.529	PSI=	48.312	PSIDOT=-246.111	PHITOT = 311.989	
T=	.06080	PHI= 127.073	PHIDOT= 150.941	PSI=	48.171	PSIDOT=-246.111	PHITOT = 312.073	
T=	.06081	PHI= 127.162	PHIDOT= 161.353	PSI=	48.030	PSIDOT=-246.111	PHITOT = 312.162	
T=	.06082	PHI= 127.258	PHIDOT= 171.765	PSI=	47.889	PSIDOT=-246.111	PHITOT = 312.256	
T=	.06083	PHI= 127.359	PHIDOT= 182.177	PSI=	47.748	PSIDOT=-246.111	PHITOT = 312.359	
T=	.06084	PHI= 127.467	PHIDOT= 192.588	PSI=	47.607	PSIDOT=-246.111	PHITOT = 312.467	
T=	.06085	PHI= 127.580	PHIDOT= 203.000	PSI=	47.466	PSIDOT=-246.111	PHITOT = 312.580	
T=	.06086	PHI= 127.699	PHIDOT= 213.412	PSI=	47.325	PSIDOT=-246.111	PHITOT = 312.699	
T=	.06087	PHI= 127.824	PHIDOT= 223.824	PSI=	47.184	PSIDOT=-246.111	PHITOT = 312.824	
T=	.06088	PHI= 127.956	PHIDOT= 234.235	PSI=	47.043	PSIDOT=-246.111	PHITOT = 312.956	
T=	.06089	PHI= 128.093	PHIDOT= 244.647	PSI=	46.902	PSIDOT=-246.111	PHITOT = 313.093	
T=	.06090	PHI= 128.236	PHIDOT= 255.059	PSI=	46.761	PSIDOT=-246.111	PHITOT = 313.236	
T=	.06091	PHI= 128.385	PHIDOT= 265.471	PSI=	46.620	PSIDOT=-246.111	PHITOT = 313.385	
T=	.06092	PHI= 128.540	PHIDOT= 275.882	PSI=	46.479	PSIDOT=-246.111	PHITOT = 313.540	
T=	.06093	PHI= 128.701	PHIDOT= 286.294	PSI=	46.338	PSIDOT=-246.111	PHITOT = 313.701	
T=	.06094	PHI= 128.868	PHIDOT= 296.706	PSI=	46.197	PSIDOT=-246.111	PHITOT = 313.868	
T=	.06095	PHI= 129.041	PHIDOT= 307.118	PSI=	46.056	PSIDOT=-246.111	PHITOT = 314.041	
T=	.06096	PHI= 129.220	PHIDOT= 317.529	PSI=	45.915	PSIDOT=-246.111	PHITOT = 314.220	
T=	.06097	PHI= 129.405	PHIDOT= 327.941	PSI=	45.774	PSIDOT=-246.111	PHITOT = 314.405	
T=	.06098	PHI= 129.596	PHIDOT= 338.353	PSI=	45.633	PSIDOT=-246.111	PHITOT = 314.596	
T=	.06099	PHI= 129.793	PHIDOT= 348.765	PSI=	45.492	PSIDOT=-246.111	PHITOT = 314.793	
T=	.06100	PHI= 129.996	PHIDOT= 359.177	PSI=	45.351	PSIDOT=-246.111	PHITOT = 314.996	

```
T=  .06101   PHI= 130.204   PHDOT= 369.588   PSI=  45.210   PSIDOT=-246.111   PHITOT = 315.204
T=  .06102   PHI= 130.419   PHDOT= 380.000   PSI=  45.089   PSIDOT=-246.111   PHITOT = 315.419
T=  .06103   PHI= 130.640   PHDOT= 390.412   PSI=  44.928   PSIDOT=-246.111   PHITOT = 315.640
T=  .06104   PHI= 130.867   PHDOT= 400.824   PSI=  44.787   PSIDOT=-246.111   PHITOT = 315.867
T=  .06105   PHI= 131.099   PHDOT= 411.235   PSI=  44.646   PSIDOT=-246.111   PHITOT = 316.099
T=  .06106   PHI= 131.338   PHDOT= 421.647   PSI=  44.505   PSIDOT=-246.111   PHITOT = 316.338
T=  .06107   PHI= 131.582   PHDOT= 432.059   PSI=  44.364   PSIDOT=-246.111   PHITOT = 316.582
T=  .06108   PHI= 131.833   PHDOT= 442.471   PSI=  44.223   PSIDOT=-246.111   PHITOT = 316.833
T=  .06109   PHI= 132.089   PHDOT= 452.882   PSI=  44.082   PSIDOT=-246.111   PHITOT = 317.089
T=  .06110   PHI= 132.352   PHDOT= 463.294   PSI=  43.941   PSIDOT=-246.111   PHITOT = 317.352
T=  .06111   PHI= 132.620   PHDOT= 473.706   PSI=  43.800   PSIDOT=-246.111   PHITOT = 317.620
T=  .06112   PHI= 132.895   PHDOT= 484.118   PSI=  43.659   PSIDOT=-246.111   PHITOT = 317.895
T=  .06113   PHI= 133.175   PHDOT= 494.529   PSI=  43.518   PSIDOT=-246.111   PHITOT = 318.175
T=  .06114   PHI= 133.461   PHDOT= 504.941   PSI=  43.377   PSIDOT=-246.111   PHITOT = 318.461
T=  .06115   PHI= 133.754   PHDOT= 515.353   PSI=  43.236   PSIDOT=-246.111   PHITOT = 318.754
T=  .06116   PHI= 134.052   PHDOT= 525.765   PSI=  43.095   PSIDOT=-246.111   PHITOT = 319.052
T=  .06117   PHI= 134.356   PHDOT= 536.177   PSI=  42.954   PSIDOT=-246.111   PHITOT = 319.356
T=  .06118   PHI= 134.666   PHDOT= 546.588   PSI=  42.813   PSIDOT=-246.111   PHITOT = 319.666
T=  .06119   PHI= 134.983   PHDOT= 557.000   PSI=  42.672   PSIDOT=-246.111   PHITOT = 319.983
T=  .06120   PHI= 135.305   PHDOT= 567.412   PSI=  42.531   PSIDOT=-246.111   PHITOT = 320.305
VP= -14.417   VS=  43.578

IMPACT

            PHI= 135.305   DPHIF=-283.971   PSI=  42.531   DPSIF=-124.799   PHITOT= 320.305
VP=  -7.311   VS= -21.809

FREE MOTION
T=  .06120   PHI= 135.305   PHDOT=-283.971   PSI=  42.531   PSIDOT=-124.799   PHITOT = 320.305
T=  .06121   PHI= 135.145   PHDOT=-273.559   PSI=  42.459   PSIDOT=-124.799   PHITOT = 320.145
VP=  -7.325   VS= -20.845

FREE MOTION
T=  .06121   PHI= 135.145   PHDOT=-273.559   PSI=  42.459   PSIDOT=-124.799   PHITOT = 320.145
T=  .06122   PHI= 134.991   PHDOT=-263.147   PSI=  42.388   PSIDOT=-124.799   PHITOT = 319.991
VP=  -7.339   VS= -19.901

FREE MOTION
T=  .06122   PHI= 134.991   PHDOT=-263.147   PSI=  42.388   PSIDOT=-124.799   PHITOT = 319.991
T=  .06123   PHI= 134.843   PHDOT=-252.735   PSI=  42.316   PSIDOT=-124.799   PHITOT = 319.843
T=  .06124   PHI= 134.702   PHDOT=-242.323   PSI=  42.245   PSIDOT=-124.799   PHITOT = 319.702
T=  .06125   PHI= 134.566   PHDOT=-231.912   PSI=  42.173   PSIDOT=-124.799   PHITOT = 319.566
T=  .06126   PHI= 134.436   PHDOT=-221.500   PSI=  42.102   PSIDOT=-124.799   PHITOT = 319.436
T=  .06127   PHI= 134.312   PHDOT=-211.088   PSI=  42.030   PSIDOT=-124.799   PHITOT = 319.312
T=  .06128   PHI= 134.194   PHDOT=-200.676   PSI=  41.959   PSIDOT=-124.799   PHITOT = 319.194
T=  .06129   PHI= 134.082   PHDOT=-190.265   PSI=  41.887   PSIDOT=-124.799   PHITOT = 319.082
T=  .06130   PHI= 133.976   PHDOT=-179.853   PSI=  41.816   PSIDOT=-124.799   PHITOT = 318.976
T=  .06131   PHI= 133.876   PHDOT=-169.441   PSI=  41.744   PSIDOT=-124.799   PHITOT = 318.876
T=  .06132   PHI= 133.782   PHDOT=-159.029   PSI=  41.673   PSIDOT=-124.799   PHITOT = 318.782
T=  .06133   PHI= 133.694   PHDOT=-148.618   PSI=  41.601   PSIDOT=-124.799   PHITOT = 318.694
T=  .06134   PHI= 133.611   PHDOT=-138.206   PSI=  41.530   PSIDOT=-124.799   PHITOT = 318.611
T=  .06135   PHI= 133.535   PHDOT=-127.794   PSI=  41.458   PSIDOT=-124.799   PHITOT = 318.535
T=  .06136   PHI= 133.465   PHDOT=-117.382   PSI=  41.387   PSIDOT=-124.799   PHITOT = 318.465
T=  .06137   PHI= 133.401   PHDOT=-106.971   PSI=  41.315   PSIDOT=-124.799   PHITOT = 318.401
T=  .06138   PHI= 133.342   PHDOT= -96.559   PSI=  41.244   PSIDOT=-124.799   PHITOT = 318.342
T=  .06139   PHI= 133.290   PHDOT= -86.147   PSI=  41.172   PSIDOT=-124.799   PHITOT = 318.290
T=  .06140   PHI= 133.244   PHDOT= -75.735   PSI=  41.101   PSIDOT=-124.799   PHITOT = 318.244
T=  .06141   PHI= 133.203   PHDOT= -65.323   PSI=  41.029   PSIDOT=-124.799   PHITOT = 318.203
T=  .06142   PHI= 133.169   PHDOT= -54.912   PSI=  40.958   PSIDOT=-124.799   PHITOT = 318.169
T=  .06143   PHI= 133.140   PHDOT= -44.500   PSI=  40.886   PSIDOT=-124.799   PHITOT = 318.140
T=  .06144   PHI= 133.118   PHDOT= -34.088   PSI=  40.815   PSIDOT=-124.799   PHITOT = 318.118
T=  .06145   PHI= 133.101   PHDOT= -23.676   PSI=  40.743   PSIDOT=-124.799   PHITOT = 318.101
T=  .06146   PHI= 133.091   PHDOT= -13.265   PSI=  40.672   PSIDOT=-124.799   PHITOT = 318.091
T=  .06147   PHI= 133.086   PHDOT=  -2.853   PSI=  40.600   PSIDOT=-124.799   PHITOT = 318.086
T=  .06148   PHI= 133.087   PHDOT=   7.559   PSI=  40.529   PSIDOT=-124.799   PHITOT = 318.087
```

```
T=  .06149   PHI= 133.095   PHDOT=  17.971   PSI=  40.457   PSIDOT=-124.799   PHITOT = 318.095
T=  .06150   PHI= 133.108   PHDOT=  28.382   PSI=  40.386   PSIDOT=-124.799   PHITOT = 318.108
T=  .06151   PHI= 133.127   PHDOT=  38.794   PSI=  40.314   PSIDOT=-124.799   PHITOT = 318.127
T=  .06152   PHI= 133.152   PHDOT=  49.206   PSI=  40.243   PSIDOT=-124.799   PHITOT = 318.152
T=  .06153   PHI= 133.186   PHDOT=  59.618   PSI=  40.171   PSIDOT=-124.799   PHITOT = 318.186
T=  .06154   PHI= 133.221   PHDOT=  70.029   PSI=  40.100   PSIDOT=-124.799   PHITOT = 318.221
VP= -7.752   VS=  4.860

IMPACT

             PHI= 133.221   DPHIF=-123.159   PSI=  40.100   DPSIF= -94.453   PHITOT= 318.221
VP= -5.489   VS= -8.517

FREE MOTION
T=  .06154   PHI= 133.221   PHDOT=-123.159   PSI=  40.100   PSIDOT= -94.453   PHITOT = 318.221
T=  .06155   PHI= 133.153   PHDOT=-112.747   PSI=  40.046   PSIDOT= -94.453   PHITOT = 318.153
VP= -5.490   VS= -7.765

FREE MOTION
T=  .06155   PHI= 133.153   PHDOT=-112.747   PSI=  40.046   PSIDOT= -94.453   PHITOT = 318.153
T=  .06156   PHI= 133.092   PHDOT=-102.336   PSI=  39.992   PSIDOT= -94.453   PHITOT = 318.092
VP= -5.491   VS= -7.025

FREE MOTION
T=  .06155   PHI= 133.092   PHDOT=-102.336   PSI=  39.992   PSIDOT= -94.453   PHITOT = 318.092
T=  .06157   PHI= 133.036   PHDOT= -91.924   PSI=  39.937   PSIDOT= -94.453   PHITOT = 318.036
VP= -5.492   VS= -6.292

FREE MOTION
T=  .06157   PHI= 133.036   PHDOT= -91.924   PSI=  39.937   PSIDOT= -94.453   PHITOT = 318.036
T=  .06158   PHI= 132.986   PHDOT= -81.512   PSI=  39.883   PSIDOT= -94.453   PHITOT = 317.986
VP= -5.491   VS= -5.564

FREE MOTION
T=  .06158   PHI= 132.986   PHDOT= -81.512   PSI=  39.883   PSIDOT= -94.453   PHITOT = 317.986
T=  .06159   PHI= 132.943   PHDOT= -71.100   PSI=  39.829   PSIDOT= -94.453   PHITOT = 317.943
VP= -5.490   VS= -4.842

IMPACT

             PHI= 132.943   DPHIF= -81.556   PSI=  39.829   DPSIF= -92.786   PHITOT= 317.943
VP= -5.393   VS= -5.555
```

APPENDIX J

COMPUTER OUTPUT FOR STANDARD CONFIGURATION WITH $\mu = .3$ AND $\varepsilon = 0$

A= .19310 B= .15838 C= .09683 R= .01365 ALPHA= 40.0000

TORQUE= .17700E-01 COFR= .30000E+00 IPAL= .91000E-07 ISTAR= .17000E-07

EREST= 0.00 LAMBDA= 109.337 DELTA= 40.000

Appendix J
Std.Config.
$\mu = .3$, $\varepsilon = 0$

Cycle No. 1

COUPLED MOTION

T= 0.00000	PHI= 135.000	PHIDOT= 0.000	G= -.0457	GDOT= 0.000	PSID= 42.412	PSIDOT= 0.000	PHITOT = -.000
T= .00000	PHI= 135.000	PHIDOT= .044	G= -.0457	GDOT= .018	PSID= 42.412	PSIDOT= .106	PHITOT = .000
T= .00000	PHI= 135.000	PHIDOT= .151	G= -.0457	GDOT= .032	PSID= 42.412	PSIDOT= .195	PHITOT = .000
T= .00000	PHI= 135.000	PHIDOT= .219	G= -.0457	GDOT= .047	PSID= 42.412	PSIDOT= .281	PHITOT = .000
T= .00001	PHI= 135.000	PHIDOT= .286	G= -.0457	GDOT= .061	PSID= 42.412	PSIDOT= .368	PHITOT = .000
T= .00001	PHI= 135.000	PHIDOT= .421	G= -.0457	GDOT= .090	PSID= 42.412	PSIDOT= .542	PHITOT = .000
T= .00001	PHI= 135.000	PHIDOT= .556	G= -.0457	GDOT= .119	PSID= 42.412	PSIDOT= .716	PHITOT = .000
T= .00002	PHI= 135.000	PHIDOT= .827	G= -.0457	GDOT= .177	PSID= 42.413	PSIDOT= 1.063	PHITOT = .000
T= .00002	PHI= 135.001	PHIDOT= 1.097	G= -.0457	GDOT= .235	PSID= 42.413	PSIDOT= 1.410	PHITOT = .001
T= .00004	PHI= 135.002	PHIDOT= 1.637	G= -.0457	GDOT= .351	PSID= 42.414	PSIDOT= 2.105	PHITOT = .002
T= .00005	PHI= 135.003	PHIDOT= 2.177	G= -.0457	GDOT= .467	PSID= 42.414	PSIDOT= 2.800	PHITOT = .003
T= .00007	PHI= 135.007	PHIDOT= 3.256	G= -.0456	GDOT= .698	PSID= 42.421	PSIDOT= 4.189	PHITOT = .007
T= .00010	PHI= 135.012	PHIDOT= 4.335	G= -.0456	GDOT= .930	PSID= 42.428	PSIDOT= 5.579	PHITOT = .012
T= .00015	PHI= 135.028	PHIDOT= 6.490	G= -.0456	GDOT= 1.392	PSID= 42.448	PSIDOT= 8.357	PHITOT = .028
T= .00020	PHI= 135.050	PHIDOT= 8.639	G= -.0455	GDOT= 1.854	PSID= 42.476	PSIDOT= 11.134	PHITOT = .050
T= .00030	PHI= 135.111	PHIDOT= 12.917	G= -.0453	GDOT= 2.774	PSID= 42.556	PSIDOT= 16.686	PHITOT = .111
T= .00040	PHI= 135.198	PHIDOT= 17.142	G= -.0449	GDOT= 3.688	PSID= 42.667	PSIDOT= 22.232	PHITOT = .198
T= .00050	PHI= 135.308	PHIDOT= 21.317	G= -.0445	GDOT= 4.594	PSID= 42.811	PSIDOT= 27.771	PHITOT = .308
T= .00060	PHI= 135.442	PHIDOT= 25.411	G= -.0440	GDOT= 5.491	PSID= 42.986	PSIDOT= 33.300	PHITOT = .442
T= .00070	PHI= 135.599	PHIDOT= 29.431	G= -.0434	GDOT= 6.376	PSID= 43.192	PSIDOT= 38.819	PHITOT = .599
T= .00080	PHI= 135.779	PHIDOT= 33.360	G= -.0427	GDOT= 7.250	PSID= 43.430	PSIDOT= 44.326	PHITOT = .779
T= .00090	PHI= 135.981	PHIDOT= 37.189	G= -.0420	GDOT= 8.109	PSID= 43.700	PSIDOT= 49.819	PHITOT = .981
T= .00100	PHI= 136.205	PHIDOT= 40.911	G= -.0411	GDOT= 8.954	PSID= 44.001	PSIDOT= 55.298	PHITOT = 1.205
T= .00110	PHI= 136.449	PHIDOT= 44.522	G= -.0402	GDOT= 9.784	PSID= 44.334	PSIDOT= 60.762	PHITOT = 1.449
T= .00120	PHI= 136.715	PHIDOT= 48.018	G= -.0392	GDOT= 10.597	PSID= 44.697	PSIDOT= 66.211	PHITOT = 1.715
T= .00130	PHI= 136.999	PHIDOT= 51.397	G= -.0381	GDOT= 11.394	PSID= 45.092	PSIDOT= 71.642	PHITOT = 1.999
T= .00140	PHI= 137.303	PHIDOT= 54.659	G= -.0369	GDOT= 12.173	PSID= 45.518	PSIDOT= 77.058	PHITOT = 2.303
T= .00150	PHI= 137.626	PHIDOT= 57.804	G= -.0356	GDOT= 12.935	PSID= 45.975	PSIDOT= 82.457	PHITOT = 2.626
T= .00160	PHI= 137.966	PHIDOT= 60.833	G= -.0343	GDOT= 13.680	PSID= 46.463	PSIDOT= 87.840	PHITOT = 2.966
T= .00170	PHI= 138.322	PHIDOT= 63.750	G= -.0329	GDOT= 14.408	PSID= 46.982	PSIDOT= 93.207	PHITOT = 3.322
T= .00180	PHI= 138.696	PHIDOT= 66.558	G= -.0314	GDOT= 15.118	PSID= 47.531	PSIDOT= 98.559	PHITOT = 3.696
T= .00190	PHI= 139.085	PHIDOT= 69.261	G= -.0299	GDOT= 15.812	PSID= 48.111	PSIDOT= 103.896	PHITOT = 4.085
T= .00200	PHI= 139.489	PHIDOT= 71.864	G= -.0282	GDOT= 16.489	PSID= 48.722	PSIDOT= 109.220	PHITOT = 4.489
T= .00210	PHI= 139.908	PHIDOT= 74.372	G= -.0266	GDOT= 17.150	PSID= 49.363	PSIDOT= 114.532	PHITOT = 4.908
T= .00220	PHI= 140.341	PHIDOT= 76.790	G= -.0248	GDOT= 17.794	PSID= 50.034	PSIDOT= 119.832	PHITOT = 5.341
T= .00230	PHI= 140.788	PHIDOT= 79.125	G= -.0230	GDOT= 18.424	PSID= 50.736	PSIDOT= 125.123	PHITOT = 5.788
T= .00240	PHI= 141.248	PHIDOT= 81.381	G= -.0211	GDOT= 19.038	PSID= 51.468	PSIDOT= 130.405	PHITOT = 6.248
T= .00250	PHI= 141.721	PHIDOT= 83.564	G= -.0192	GDOT= 19.637	PSID= 52.230	PSIDOT= 135.680	PHITOT = 6.721
T= .00260	PHI= 142.205	PHIDOT= 85.681	G= -.0172	GDOT= 20.221	PSID= 53.023	PSIDOT= 140.950	PHITOT = 7.205
T= .00270	PHI= 142.702	PHIDOT= 87.740	G= -.0152	GDOT= 20.792	PSID= 53.845	PSIDOT= 146.216	PHITOT = 7.702
T= .00280	PHI= 143.211	PHIDOT= 89.741	G= -.0131	GDOT= 21.349	PSID= 54.698	PSIDOT= 151.480	PHITOT = 8.211
T= .00290	PHI= 143.731	PHIDOT= 91.692	G= -.0109	GDOT= 21.892	PSID= 55.581	PSIDOT= 156.743	PHITOT = 8.731
T= .00300	PHI= 144.261	PHIDOT= 93.598	G= -.0087	GDOT= 22.421	PSID= 56.494	PSIDOT= 162.008	PHITOT = 9.261
T= .00310	PHI= 144.803	PHIDOT= 95.461	G= -.0064	GDOT= 22.938	PSID= 57.438	PSIDOT= 167.275	PHITOT = 9.803
T= .00320	PHI= 145.355	PHIDOT= 97.292	G= -.0041	GDOT= 23.441	PSID= 58.411	PSIDOT= 172.547	PHITOT = 10.355
T= .00330	PHI= 145.918	PHIDOT= 99.090	G= -.0017	GDOT= 23.931	PSID= 59.415	PSIDOT= 177.825	PHITOT = 10.918
T= .00340	PHI= 146.491	PHIDOT= 100.859	G= .0007	GDOT= 24.408	PSID= 60.449	PSIDOT= 183.111	PHITOT = 11.491

FREE MOTION

```
T=  .00340   PHI= 186.491   PHIDOT= 100.859   PSI= 311.116   PSIDOT= 183.111   PHITOT =  11.491
T=  .00341   PHI= 186.551   PHIDOT= 111.271   PSI= 311.217   PSIDOT= 183.111   PHITOT =  11.551
T=  .00342   PHI= 186.618   PHIDOT= 121.453   PSI= 311.322   PSIDOT= 183.111   PHITOT =  11.618
T=  .00343   PHI= 186.691   PHIDOT= 132.095   PSI= 311.427   PSIDOT= 183.111   PHITOT =  11.691
T=  .00344   PHI= 186.770   PHIDOT= 142.506   PSI= 311.532   PSIDOT= 183.111   PHITOT =  11.770
T=  .00345   PHI= 186.854   PHIDOT= 152.918   PSI= 311.637   PSIDOT= 183.111   PHITOT =  11.854
T=  .00346   PHI= 186.945   PHIDOT= 163.330   PSI= 311.742   PSIDOT= 183.111   PHITOT =  11.945
T=  .00347   PHI= 187.041   PHIDOT= 173.742   PSI= 311.846   PSIDOT= 183.111   PHITOT =  12.041
T=  .00348   PHI= 187.144   PHIDOT= 184.153   PSI= 311.951   PSIDOT= 183.111   PHITOT =  12.144
T=  .00349   PHI= 187.252   PHIDOT= 194.565   PSI= 312.056   PSIDOT= 183.111   PHITOT =  12.252
T=  .00350   PHI= 187.367   PHIDOT= 204.977   PSI= 312.161   PSIDOT= 183.111   PHITOT =  12.367
T=  .00351   PHI= 187.487   PHIDOT= 215.389   PSI= 312.266   PSIDOT= 183.111   PHITOT =  12.487
T=  .00352   PHI= 187.614   PHIDOT= 225.800   PSI= 312.371   PSIDOT= 183.111   PHITOT =  12.614
T=  .00353   PHI= 187.746   PHIDOT= 236.212   PSI= 312.476   PSIDOT= 183.111   PHITOT =  12.746
T=  .00354   PHI= 187.884   PHIDOT= 246.624   PSI= 312.581   PSIDOT= 183.111   PHITOT =  12.884
T=  .00355   PHI= 188.029   PHIDOT= 257.036   PSI= 312.686   PSIDOT= 183.111   PHITOT =  13.029
T=  .00356   PHI= 188.179   PHIDOT= 267.447   PSI= 312.791   PSIDOT= 183.111   PHITOT =  13.179
T=  .00357   PHI= 188.335   PHIDOT= 277.859   PSI= 312.896   PSIDOT= 183.111   PHITOT =  13.335
T=  .00358   PHI= 188.497   PHIDOT= 288.271   PSI= 313.001   PSIDOT= 183.111   PHITOT =  13.497
T=  .00359   PHI= 188.665   PHIDOT= 298.683   PSI= 313.105   PSIDOT= 183.111   PHITOT =  13.665
T=  .00360   PHI= 188.840   PHIDOT= 309.095   PSI= 313.210   PSIDOT= 183.111   PHITOT =  13.840
T=  .00361   PHI= 189.020   PHIDOT= 319.506   PSI= 313.315   PSIDOT= 183.111   PHITOT =  14.020
T=  .00362   PHI= 189.206   PHIDOT= 329.918   PSI= 313.420   PSIDOT= 183.111   PHITOT =  14.206
T=  .00363   PHI= 189.398   PHIDOT= 340.330   PSI= 313.525   PSIDOT= 183.111   PHITOT =  14.398
T=  .00364   PHI= 189.596   PHIDOT= 350.742   PSI= 313.630   PSIDOT= 183.111   PHITOT =  14.596
T=  .00365   PHI= 189.800   PHIDOT= 361.153   PSI= 313.735   PSIDOT= 183.111   PHITOT =  14.800
T=  .00366   PHI= 190.010   PHIDOT= 371.565   PSI= 313.840   PSIDOT= 183.111   PHITOT =  15.010
T=  .00367   PHI= 190.225   PHIDOT= 381.977   PSI= 313.945   PSIDOT= 183.111   PHITOT =  15.225
T=  .00368   PHI= 190.447   PHIDOT= 392.389   PSI= 314.050   PSIDOT= 183.111   PHITOT =  15.447
T=  .00369   PHI= 190.675   PHIDOT= 402.800   PSI= 314.155   PSIDOT= 183.111   PHITOT =  15.675
T=  .00370   PHI= 190.909   PHIDOT= 413.212   PSI= 314.260   PSIDOT= 183.111   PHITOT =  15.909
T=  .00371   PHI= 191.149   PHIDOT= 423.624   PSI= 314.364   PSIDOT= 183.111   PHITOT =  16.149
T=  .00372   PHI= 191.394   PHIDOT= 434.036   PSI= 314.469   PSIDOT= 183.111   PHITOT =  16.394
T=  .00373   PHI= 191.646   PHIDOT= 444.447   PSI= 314.574   PSIDOT= 183.111   PHITOT =  16.646
T=  .00374   PHI= 191.904   PHIDOT= 454.859   PSI= 314.679   PSIDOT= 183.111   PHITOT =  16.904
T=  .00375   PHI= 192.167   PHIDOT= 465.271   PSI= 314.784   PSIDOT= 183.111   PHITOT =  17.167
T=  .00376   PHI= 192.437   PHIDOT= 475.683   PSI= 314.889   PSIDOT= 183.111   PHITOT =  17.437
T=  .00377   PHI= 192.712   PHIDOT= 486.095   PSI= 314.994   PSIDOT= 183.111   PHITOT =  17.712
T=  .00378   PHI= 192.994   PHIDOT= 496.506   PSI= 315.099   PSIDOT= 183.111   PHITOT =  17.994
T=  .00379   PHI= 193.281   PHIDOT= 506.918   PSI= 315.204   PSIDOT= 183.111   PHITOT =  18.281
T=  .00380   PHI= 193.575   PHIDOT= 517.330   PSI= 315.309   PSIDOT= 183.111   PHITOT =  18.575
T=  .00381   PHI= 193.874   PHIDOT= 527.742   PSI= 315.414   PSIDOT= 183.111   PHITOT =  18.874
T=  .00382   PHI= 194.179   PHIDOT= 538.153   PSI= 315.518   PSIDOT= 183.111   PHITOT =  19.179
VP= -16.798   VS=  44.239

IMPACT

                PHI= 194.179   DPHIF= -64.204   PSI= 315.518   DPSIF=  57.532   PHITOT=  19.179
VP=  -5.278   VS=  -5.278

COUPLED MOTION
T=  .00382   PHI= 194.179   PHIDOT= -64.204   G=  -.0391   GDOT=  -9.219   PSID= 315.269   PSIDOT=  57.411   PHITOT =  19.179
T=  .00392   PHI= 193.894   PHIDOT= -35.093   G=  -.0398   GDOT=  -5.000   PSID= 315.544   PSIDOT=  31.115   PHITOT =  18.894
T=  .00402   PHI= 193.779   PHIDOT=  -5.240   G=  -.0401   GDOT=   -.744   PSID= 315.646   PSIDOT=   6.624   PHITOT =  18.779
T=  .00403   PHI= 193.777   PHIDOT=  -3.363   G=  -.0401   GDOT=   -.478   PSID= 315.647   PSIDOT=   2.968   PHITOT =  18.777
T=  .00403   PHI= 193.776   PHIDOT=  -1.487   G=  -.0401   GDOT=   -.211   PSID= 315.648   PSIDOT=  1.312   PHITOT =  18.776
T=  .00403   PHI= 193.776   PHIDOT=  -1.018   G=  -.0401   GDOT=   -.145   PSID= 315.648   PSIDOT=   .898   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   -.549   G=  -.0401   GDOT=   -.078   PSID= 315.648   PSIDOT=   .484   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   -.314   G=  -.0401   GDOT=   -.045   PSID= 315.648   PSIDOT=   .277   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   -.080   G=  -.0401   GDOT=   -.011   PSID= 315.648   PSIDOT=   .070   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .055   G=  -.0401   GDOT=    .008   PSID= 315.648   PSIDOT=  -.049   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .171   G=  -.0401   GDOT=    .024   PSID= 315.648   PSIDOT=  -.151   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .284   G=  -.0401   GDOT=    .041   PSID= 315.648   PSIDOT=  -.252   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .401   G=  -.0401   GDOT=    .057   PSID= 315.648   PSIDOT=  -.354   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .514   G=  -.0401   GDOT=    .073   PSID= 315.648   PSIDOT=  -.456   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .631   G=  -.0401   GDOT=    .090   PSID= 315.648   PSIDOT=  -.557   PHITOT =  18.776
```

T= .00404 PHI= 193.776 PHIDOT= .862 G= -.0401 GDOT= .122 PSID= 315.648 PSIDOT= -.780 PHITOT = 18.776
T= .00404 PHI= 193.776 PHIDOT= 1.092 G= -.0401 GDOT= .145 PSID= 315.648 PSIDOT= -.964 PHITOT = 18.776
T= .00405 PHI= 193.776 PHIDOT= 1.553 G= -.0401 GDOT= .221 PSID= 315.648 PSIDOT= -1.378 PHITOT = 18.776
T= .00405 PHI= 193.777 PHIDOT= 2.014 G= -.0401 GDOT= .296 PSID= 315.648 PSIDOT= -1.777 PHITOT = 18.777
T= .00405 PHI= 193.777 PHIDOT= 2.474 G= -.0401 GDOT= .351 PSID= 315.647 PSIDOT= -2.184 PHITOT = 18.777
T= .00406 PHI= 193.778 PHIDOT= 2.935 G= -.0401 GDOT= .417 PSID= 315.647 PSIDOT= -2.590 PHITOT = 18.778
T= .00406 PHI= 193.779 PHIDOT= 3.856 G= -.0401 GDOT= .548 PSID= 315.644 PSIDOT= -3.403 PHITOT = 18.779
T= .00407 PHI= 193.780 PHIDOT= 4.778 G= -.0401 GDOT= .679 PSID= 315.644 PSIDOT= -4.216 PHITOT = 18.780
T= .00408 PHI= 193.785 PHIDOT= 6.619 G= -.0401 GDOT= .940 PSID= 315.641 PSIDOT= -5.843 PHITOT = 18.785
T= .00409 PHI= 193.790 PHIDOT= 8.459 G= -.0401 GDOT= 1.202 PSID= 315.636 PSIDOT= -7.469 PHITOT = 18.790
T= .00411 PHI= 193.797 PHIDOT= 10.298 G= -.0401 GDOT= 1.463 PSID= 315.630 PSIDOT= -9.094 PHITOT = 18.797
T= .00412 PHI= 193.805 PHIDOT= 12.135 G= -.0401 GDOT= 1.725 PSID= 315.623 PSIDOT= -10.720 PHITOT = 18.805
T= .00414 PHI= 193.825 PHIDOT= 15.901 G= -.0400 GDOT= 2.247 PSID= 315.605 PSIDOT= -13.970 PHITOT = 18.825
T= .00417 PHI= 193.850 PHIDOT= 19.455 G= -.0399 GDOT= 2.749 PSID= 315.583 PSIDOT= -17.219 PHITOT = 18.850
T= .00419 PHI= 193.880 PHIDOT= 23.094 G= -.0399 GDOT= 3.249 PSID= 315.556 PSIDOT= -20.466 PHITOT = 18.880
T= .00422 PHI= 193.916 PHIDOT= 26.718 G= -.0398 GDOT= 3.809 PSID= 315.524 PSIDOT= -23.711 PHITOT = 18.916
T= .00427 PHI= 194.003 PHIDOT= 33.894 G= -.0396 GDOT= 4.844 PSID= 315.447 PSIDOT= -30.192 PHITOT = 19.003
T= .00432 PHI= 194.110 PHIDOT= 40.976 G= -.0393 GDOT= 5.872 PSID= 315.351 PSIDOT= -36.660 PHITOT = 19.110
T= .00437 PHI= 194.238 PHIDOT= 47.929 G= -.0390 GDOT= 6.893 PSID= 315.237 PSIDOT= -43.112 PHITOT = 19.238
T= .00442 PHI= 194.385 PHIDOT= 54.741 G= -.0386 GDOT= 7.906 PSID= 315.104 PSIDOT= -49.545 PHITOT = 19.385
T= .00452 PHI= 194.736 PHIDOT= 67.861 G= -.0377 GDOT= 9.895 PSID= 314.784 PSIDOT= -62.339 PHITOT = 19.736
T= .00462 PHI= 195.161 PHIDOT= 80.164 G= -.0366 GDOT= 11.834 PSID= 314.390 PSIDOT= -75.016 PHITOT = 20.161
T= .00472 PHI= 195.653 PHIDOT= 91.591 G= -.0353 GDOT= 13.713 PSID= 313.925 PSIDOT= -87.544 PHITOT = 20.653
T= .00482 PHI= 196.208 PHIDOT= 101.968 G= -.0339 GDOT= 15.524 PSID= 313.387 PSIDOT= -99.898 PHITOT = 21.208
T= .00492 PHI= 196.820 PHIDOT= 111.227 G= -.0322 GDOT= 17.241 PSID= 312.780 PSIDOT=-112.043 PHITOT = 21.820
T= .00502 PHI= 197.481 PHIDOT= 119.303 G= -.0304 GDOT= 18.917 PSID= 312.104 PSIDOT=-123.943 PHITOT = 22.481
T= .00512 PHI= 198.184 PHIDOT= 126.144 G= -.0285 GDOT= 20.448 PSID= 311.368 PSIDOT=-135.564 PHITOT = 23.184
T= .00522 PHI= 198.924 PHIDOT= 131.740 G= -.0263 GDOT= 21.968 PSID= 310.551 PSIDOT=-146.972 PHITOT = 23.924
T= .00532 PHI= 199.692 PHIDOT= 136.076 G= -.0241 GDOT= 23.355 PSID= 309.678 PSIDOT=-157.832 PHITOT = 24.692
T= .00542 PHI= 200.481 PHIDOT= 139.172 G= -.0217 GDOT= 24.646 PSID= 308.743 PSIDOT=-168.411 PHITOT = 25.481
T= .00552 PHI= 201.284 PHIDOT= 141.066 G= -.0191 GDOT= 25.819 PSID= 307.749 PSIDOT=-178.578 PHITOT = 26.284
T= .00562 PHI= 202.095 PHIDOT= 141.801 G= -.0165 GDOT= 26.933 PSID= 306.698 PSIDOT=-188.306 PHITOT = 27.045
T= .00572 PHI= 202.907 PHIDOT= 141.450 G= -.0138 GDOT= 27.927 PSID= 305.592 PSIDOT=-197.562 PHITOT = 27.907
T= .00582 PHI= 203.714 PHIDOT= 140.084 G= -.0109 GDOT= 28.822 PSID= 304.435 PSIDOT=-206.332 PHITOT = 28.714
T= .00592 PHI= 204.511 PHIDOT= 137.796 G= -.0080 GDOT= 29.618 PSID= 303.229 PSIDOT=-214.595 PHITOT = 29.511
T= .00602 PHI= 205.291 PHIDOT= 134.667 G= -.0050 GDOT= 30.317 PSID= 301.977 PSIDOT=-222.337 PHITOT = 30.291
T= .00612 PHI= 206.052 PHIDOT= 130.800 G= -.0019 GDOT= 30.920 PSID= 300.682 PSIDOT=-229.549 PHITOT = 31.052
T= .00622 PHI= 206.789 PHIDOT= 126.289 G= .0012 GDOT= 31.429 PSID= 299.347 PSIDOT=-236.225 PHITOT = 31.789

FREE MOTION

T= .00622 PHI= 126.789 PHDOT= 126.289 PSI= 48.684 PSIDOT=-236.225 PHITOT = 31.789
T= .00623 PHI= 126.864 PHDOT= 136.700 PSI= 48.549 PSIDOT=-236.225 PHITOT = 31.864
T= .00624 PHI= 126.946 PHDOT= 147.112 PSI= 48.414 PSIDOT=-236.225 PHITOT = 31.946
T= .00625 PHI= 127.033 PHDOT= 157.524 PSI= 48.278 PSIDOT=-236.225 PHITOT = 32.033
T= .00626 PHI= 127.126 PHDOT= 167.936 PSI= 48.143 PSIDOT=-236.225 PHITOT = 32.126
T= .00627 PHI= 127.225 PHDOT= 178.347 PSI= 48.008 PSIDOT=-236.225 PHITOT = 32.225
T= .00628 PHI= 127.331 PHDOT= 188.759 PSI= 47.872 PSIDOT=-236.225 PHITOT = 32.331
T= .00629 PHI= 127.442 PHDOT= 199.171 PSI= 47.737 PSIDOT=-236.225 PHITOT = 32.442
T= .00630 PHI= 127.559 PHDOT= 209.583 PSI= 47.602 PSIDOT=-236.225 PHITOT = 32.559
T= .00631 PHI= 127.682 PHDOT= 219.994 PSI= 47.466 PSIDOT=-236.225 PHITOT = 32.682
T= .00632 PHI= 127.811 PHDOT= 230.406 PSI= 47.331 PSIDOT=-236.225 PHITOT = 32.811
T= .00633 PHI= 127.946 PHDOT= 240.818 PSI= 47.196 PSIDOT=-236.225 PHITOT = 32.946
T= .00634 PHI= 128.087 PHDOT= 251.230 PSI= 47.060 PSIDOT=-236.225 PHITOT = 33.087
T= .00635 PHI= 128.234 PHDOT= 261.642 PSI= 46.925 PSIDOT=-236.225 PHITOT = 33.234
T= .00636 PHI= 128.387 PHDOT= 272.053 PSI= 46.790 PSIDOT=-236.225 PHITOT = 33.387
T= .00637 PHI= 128.546 PHDOT= 282.465 PSI= 46.654 PSIDOT=-236.225 PHITOT = 33.546
T= .00638 PHI= 128.710 PHDOT= 292.877 PSI= 46.519 PSIDOT=-236.225 PHITOT = 33.710
T= .00639 PHI= 128.881 PHDOT= 303.289 PSI= 46.383 PSIDOT=-236.225 PHITOT = 33.881
T= .00640 PHI= 129.058 PHDOT= 313.700 PSI= 46.248 PSIDOT=-236.225 PHITOT = 34.058
T= .00641 PHI= 129.241 PHDOT= 324.112 PSI= 46.112 PSIDOT=-236.225 PHITOT = 34.241
T= .00642 PHI= 129.429 PHDOT= 334.524 PSI= 45.977 PSIDOT=-236.225 PHITOT = 34.429
T= .00643 PHI= 129.624 PHDOT= 344.936 PSI= 45.842 PSIDOT=-236.225 PHITOT = 34.624
T= .00644 PHI= 129.825 PHDOT= 355.347 PSI= 45.707 PSIDOT=-236.225 PHITOT = 34.825
T= .00645 PHI= 130.031 PHDOT= 365.759 PSI= 45.571 PSIDOT=-236.225 PHITOT = 35.031
T= .00646 PHI= 130.244 PHDOT= 376.171 PSI= 45.436 PSIDOT=-236.225 PHITOT = 35.244
T= .00647 PHI= 130.462 PHDOT= 386.583 PSI= 45.301 PSIDOT=-236.225 PHITOT = 35.462

```
     T=  .00648   PHI= 130.687   PHIDOT= 393.994   PSI=  45.165   PSIDOT=-236.225   PHITOT =  35.887
     T=  .00649   PHI= 130.917   PHIDOT= 407.406   PSI=  45.070   PSIDOT=-236.225   PHITOT =  35.917
     T=  .00650   PHI= 131.154   PHIDOT= 417.818   PSI=  44.995   PSIDOT=-236.225   PHITOT =  36.154
     T=  .00651   PHI= 131.396   PHIDOT= 428.230   PSI=  44.759   PSIDOT=-236.225   PHITOT =  36.396
     T=  .00652   PHI= 131.644   PHIDOT= 438.642   PSI=  44.624   PSIDOT=-236.225   PHITOT =  36.644
     T=  .00653   PHI= 131.899   PHIDOT= 449.053   PSI=  44.489   PSIDOT=-236.225   PHITOT =  36.899
     T=  .00654   PHI= 132.159   PHIDOT= 459.465   PSI=  44.353   PSIDOT=-236.225   PHITOT =  37.159
     T=  .00655   PHI= 132.425   PHIDOT= 469.877   PSI=  44.218   PSIDOT=-236.225   PHITOT =  37.425
     T=  .00656   PHI= 132.697   PHIDOT= 480.289   PSI=  44.083   PSIDOT=-236.225   PHITOT =  37.697
     T=  .00657   PHI= 132.975   PHIDOT= 490.700   PSI=  43.947   PSIDOT=-236.225   PHITOT =  37.975
     T=  .00658   PHI= 133.260   PHIDOT= 501.112   PSI=  43.812   PSIDOT=-236.225   PHITOT =  38.260
     T=  .00659   PHI= 133.550   PHIDOT= 511.524   PSI=  43.677   PSIDOT=-236.225   PHITOT =  38.550
     T=  .00660   PHI= 133.846   PHIDOT= 521.936   PSI=  43.541   PSIDOT=-236.225   PHITOT =  38.846
     T=  .00661   PHI= 134.148   PHIDOT= 532.347   PSI=  43.406   PSIDOT=-236.225   PHITOT =  39.148
     T=  .00662   PHI= 134.456   PHIDOT= 542.759   PSI=  43.271   PSIDOT=-236.225   PHITOT =  39.456
     T=  .00663   PHI= 134.770   PHIDOT= 553.171   PSI=  43.135   PSIDOT=-236.225   PHITOT =  39.770
     T=  .00664   PHI= 135.090   PHIDOT= 563.583   PSI=  43.000   PSIDOT=-236.225   PHITOT =  40.090
     T=  .00665   PHI= 135.416   PHIDOT= 573.994   PSI=  42.864   PSIDOT=-236.225   PHITOT =  40.416
VP= -13.908   VS=  44.323

     IMPACT      Cycle No. 2

                 PHI= 135.416   DPHIF=-106.237   PSI=  42.864   DPSIF=-139.131   PHITOT=  40.416
VP=  -8.204   VS=  -8.204

     COUPLED MOTION
     T=  .00665   PHI= 135.416   PHIDOT=-106.237   G=  -.0441   GDOT= -22.943   PSID=  42.951   PSIDOT=-139.056   PHITOT =  40.416
     T=  .00675   PHI= 134.865   PHIDOT= -85.719   G=  -.0462   GDOT= -18.329   PSID=  42.239   PSIDOT=-109.593   PHITOT =  39.565
     T=  .00685   PHI= 134.437   PHIDOT= -63.431   G=  -.0478   GDOT= -13.457   PSID=  41.697   PSIDOT= -79.594   PHITOT =  39.137
     T=  .00695   PHI= 134.141   PHIDOT= -39.763   G=  -.0489   GDOT=  -8.385   PSID=  41.327   PSIDOT= -49.211   PHITOT =  38.841
     T=  .00705   PHI= 133.983   PHIDOT= -15.124   G=  -.0494   GDOT=  -3.142   PSID=  41.133   PSIDOT= -18.596   PHITOT =  38.983
     T=  .00707   PHI= 133.966   PHIDOT=  -8.899   G=  -.0495   GDOT=  -1.870   PSID=  41.112   PSIDOT= -10.923   PHITOT =  38.966
     T=  .00710   PHI= 133.958   PHIDOT=  -2.664   G=  -.0495   GDOT=   -.556   PSID=  41.107   PSIDOT=  -3.246   PHITOT =  38.958
     T=  .00710   PHI= 133.957   PHIDOT=  -1.869   G=  -.0495   GDOT=   -.392   PSID=  41.101   PSIDOT=  -2.287   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=  -1.081   G=  -.0495   GDOT=   -.227   PSID=  41.101   PSIDOT=  -1.327   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=   -.698   G=  -.0495   GDOT=   -.145   PSID=  41.101   PSIDOT=   -.847   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=   -.299   G=  -.0495   GDOT=   -.063   PSID=  41.101   PSIDOT=   -.368   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=   -.104   G=  -.0495   GDOT=   -.022   PSID=  41.101   PSIDOT=   -.128   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=    .065   G=  -.0495   GDOT=    .014   PSID=  41.101   PSIDOT=    .080   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=    .101   G=  -.0495   GDOT=    .021   PSID=  41.101   PSIDOT=    .124   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=    .137   G=  -.0495   GDOT=    .029   PSID=  41.101   PSIDOT=    .168   PHITOT =  38.957
     T=  .00711   PHI= 133.957   PHIDOT=    .209   G=  -.0495   GDOT=    .044   PSID=  41.101   PSIDOT=    .257   PHITOT =  38.957
     T=  .00712   PHI= 133.957   PHIDOT=    .281   G=  -.0495   GDOT=    .059   PSID=  41.101   PSIDOT=    .346   PHITOT =  38.957
     T=  .00712   PHI= 133.957   PHIDOT=    .354   G=  -.0495   GDOT=    .074   PSID=  41.101   PSIDOT=    .436   PHITOT =  38.957
     T=  .00712   PHI= 133.957   PHIDOT=    .424   G=  -.0495   GDOT=    .089   PSID=  41.101   PSIDOT=    .523   PHITOT =  38.957
     T=  .00712   PHI= 133.957   PHIDOT=    .570   G=  -.0495   GDOT=    .120   PSID=  41.101   PSIDOT=    .700   PHITOT =  38.957
     T=  .00712   PHI= 133.957   PHIDOT=    .716   G=  -.0495   GDOT=    .150   PSID=  41.101   PSIDOT=    .877   PHITOT =  38.957
     T=  .00713   PHI= 133.957   PHIDOT=   1.003   G=  -.0495   GDOT=    .211   PSID=  41.102   PSIDOT=   1.231   PHITOT =  38.957
     T=  .00714   PHI= 133.958   PHIDOT=   1.291   G=  -.0495   GDOT=    .272   PSID=  41.102   PSIDOT=   1.586   PHITOT =  38.958
     T=  .00714   PHI= 133.958   PHIDOT=   1.588   G=  -.0495   GDOT=    .332   PSID=  41.103   PSIDOT=   1.940   PHITOT =  38.958
     T=  .00715   PHI= 133.959   PHIDOT=   1.862   G=  -.0495   GDOT=    .393   PSID=  41.104   PSIDOT=   2.295   PHITOT =  38.959
     T=  .00716   PHI= 133.961   PHIDOT=   2.446   G=  -.0495   GDOT=    .514   PSID=  41.105   PSIDOT=   3.003   PHITOT =  38.961
     T=  .00717   PHI= 133.962   PHIDOT=   3.022   G=  -.0495   GDOT=    .635   PSID=  41.108   PSIDOT=   3.712   PHITOT =  38.962
     T=  .00719   PHI= 133.965   PHIDOT=   3.598   G=  -.0495   GDOT=    .757   PSID=  41.111   PSIDOT=   4.421   PHITOT =  38.965
     T=  .00720   PHI= 133.968   PHIDOT=   4.175   G=  -.0495   GDOT=    .878   PSID=  41.114   PSIDOT=   5.130   PHITOT =  38.968
     T=  .00722   PHI= 133.974   PHIDOT=   5.327   G=  -.0495   GDOT=   1.120   PSID=  41.123   PSIDOT=   6.547   PHITOT =  38.974
     T=  .00725   PHI= 133.983   PHIDOT=   6.478   G=  -.0494   GDOT=   1.363   PSID=  41.133   PSIDOT=   7.964   PHITOT =  38.983
     T=  .00730   PHI= 134.005   PHIDOT=   8.774   G=  -.0494   GDOT=   1.846   PSID=  41.166   PSIDOT=  10.797   PHITOT =  39.005
     T=  .00735   PHI= 134.033   PHIDOT=  11.061   G=  -.0493   GDOT=   2.329   PSID=  41.195   PSIDOT=  13.630   PHITOT =  39.033
     T=  .00740   PHI= 134.068   PHIDOT=  13.337   G=  -.0491   GDOT=   2.810   PSID=  41.238   PSIDOT=  16.466   PHITOT =  39.068
     T=  .00745   PHI= 134.110   PHIDOT=  15.606   G=  -.0490   GDOT=   3.289   PSID=  41.289   PSIDOT=  19.289   PHITOT =  39.110
     T=  .00755   PHI= 134.212   PHIDOT=  20.074   G=  -.0486   GDOT=   4.242   PSID=  41.414   PSIDOT=  24.941   PHITOT =  39.212
     T=  .00765   PHI= 134.340   PHIDOT=  24.478   G=  -.0481   GDOT=   5.184   PSID=  41.575   PSIDOT=  30.582   PHITOT =  39.340
     T=  .00775   PHI= 134.492   PHIDOT=  28.787   G=  -.0476   GDOT=   6.114   PSID=  41.766   PSIDOT=  36.210   PHITOT =  39.492
     T=  .00785   PHI= 134.669   PHIDOT=  32.991   G=  -.0469   GDOT=   7.030   PSID=  41.990   PSIDOT=  41.824   PHITOT =  39.669
     T=  .00795   PHI= 134.870   PHIDOT=  37.081   G=  -.0462   GDOT=   7.930   PSID=  42.245   PSIDOT=  47.422   PHITOT =  39.870
```

T= .00805 PHI= 134.094 PHIDOT= 41.047 G= -.0453 GDOT= 8.816 PSID= 42.533 PSIDOT= 53.002 PHITOT = 40.040
T= .00815 PHI= 135.340 PHIDOT= 44.886 G= -.0444 GDOT= 9.640 PSID= 42.853 PSIDOT= 54.563 PHITOT = 40.340
T= .00825 PHI= 135.603 PHIDOT= 48.585 G= -.0434 GDOT= 10.528 PSID= 43.204 PSIDOT= 64.104 PHITOT = 40.404
T= .00835 PHI= 135.897 PHIDOT= 52.159 G= -.0423 GDOT= 11.356 PSID= 43.587 PSIDOT= 69.625 PHITOT = 40.897
T= .00845 PHI= 136.205 PHIDOT= 55.577 G= -.0411 GDOT= 12.145 PSID= 44.002 PSIDOT= 75.124 PHITOT = 41.205
T= .00855 PHI= 136.533 PHIDOT= 58.864 G= -.0399 GDOT= 12.954 PSID= 44.448 PSIDOT= 80.602 PHITOT = 41.533
T= .00865 PHI= 136.880 PHIDOT= 62.020 G= -.0385 GDOT= 13.723 PSID= 44.926 PSIDOT= 86.058 PHITOT = 41.880
T= .00875 PHI= 137.244 PHIDOT= 65.042 G= -.0371 GDOT= 14.472 PSID= 45.436 PSIDOT= 91.493 PHITOT = 42.244
T= .00885 PHI= 137.625 PHIDOT= 67.934 G= -.0356 GDOT= 15.203 PSID= 45.974 PSIDOT= 96.908 PHITOT = 42.625
T= .00895 PHI= 138.022 PHIDOT= 70.709 G= -.0341 GDOT= 15.914 PSID= 46.545 PSIDOT= 102.303 PHITOT = 43.022
T= .00905 PHI= 138.435 PHIDOT= 73.365 G= -.0324 GDOT= 16.606 PSID= 47.144 PSIDOT= 107.679 PHITOT = 43.435
T= .00915 PHI= 138.862 PHIDOT= 75.911 G= -.0308 GDOT= 17.280 PSID= 47.779 PSIDOT= 113.037 PHITOT = 43.862
T= .00925 PHI= 139.304 PHID T= 78.354 G= -.0290 GDOT= 17.937 PSID= 48.442 PSIDOT= 118.379 PHITOT = 44.304
T= .00935 PHI= 139.760 PHIDOT= 80.701 G= -.0272 GDOT= 18.577 PSID= 49.135 PSIDOT= 123.705 PHITOT = 44.760
T= .00945 PHI= 140.229 PHIDOT= 82.959 G= -.0253 GDOT= 19.200 PSID= 49.859 PSIDOT= 129.019 PHITOT = 45.229
T= .00955 PHI= 140.711 PHIDOT= 85.134 G= -.0233 GDOT= 19.807 PSID= 50.613 PSIDOT= 134.321 PHITOT = 45.711
T= .00965 PHI= 141.204 PHIDOT= 87.235 G= -.0213 GDOT= 20.398 PSID= 51.398 PSIDOT= 139.612 PHITOT = 46.204
T= .00975 PHI= 141.710 PHIDOT= 89.267 G= -.0192 GDOT= 20.974 PSID= 52.213 PSIDOT= 144.896 PHITOT = 46.710
T= .00985 PHI= 142.227 PHIDOT= 91.232 G= -.0171 GDOT= 21.536 PSID= 53.059 PSIDOT= 150.173 PHITOT = 47.227
T= .00995 PHI= 142.755 PHIDOT= 93.152 G= -.0149 GDOT= 22.044 PSID= 53.934 PSIDOT= 155.446 PHITOT = 47.755
T= .01005 PHI= 143.295 PHIDOT= 95.017 G= -.0127 GDOT= 22.617 PSID= 54.840 PSIDOT= 160.716 PHITOT = 48.295
T= .01015 PHI= 143.844 PHIDOT= 96.837 G= -.0104 GDOT= 23.137 PSID= 55.776 PSIDOT= 165.986 PHITOT = 48.844
T= .01025 PHI= 144.404 PHIDOT= 98.618 G= -.0081 GDOT= 23.644 PSID= 56.742 PSIDOT= 171.257 PHITOT = 49.404
T= .01035 PHI= 144.974 PHIDOT= 100.365 G= -.0057 GDOT= 24.137 PSID= 57.739 PSIDOT= 176.531 PHITOT = 49.974
T= .01045 PHI= 145.554 PHIDOT= 102.083 G= -.0032 GDOT= 24.617 PSID= 58.765 PSIDOT= 181.810 PHITOT = 50.554
T= .01055 PHI= 146.144 PHIDOT= 103.774 G= -.0008 GDOT= 25.084 PSID= 59.822 PSIDOT= 187.096 PHITOT = 51.144
T= .01065 PHI= 146.743 PHIDOT= 105.444 G= .0018 GDOT= 25.537 PSID= 60.909 PSIDOT= 192.390 PHITOT = 51.743

FREE MOTION
T= .01065 PHI= 186.743 PHDOT= 105.444 PSI= 311.572 PSIDOT= 192.390 PHITOT = 51.743
T= .01066 PHI= 186.807 PHDOT= 115.856 PSI= 311.682 PSIDOT= 192.390 PHITOT = 51.807
T= .01067 PHI= 186.876 PHDOT= 126.268 PSI= 311.792 PSIDOT= 192.390 PHITOT = 51.876
T= .01068 PHI= 186.951 PHDOT= 136.680 PSI= 311.903 PSIDOT= 192.390 PHITOT = 51.951
T= .01069 PHI= 187.033 PHDOT= 147.092 PSI= 312.013 PSIDOT= 192.390 PHITOT = 52.033
T= .01070 PHI= 187.120 PHDOT= 157.503 PSI= 312.123 PSIDOT= 192.390 PHITOT = 52.120
T= .01071 PHI= 187.213 PHDOT= 167.915 PSI= 312.233 PSIDOT= 192.390 PHITOT = 52.213
T= .01072 PHI= 187.312 PHDOT= 178.327 PSI= 312.343 PSIDOT= 192.390 PHITOT = 52.312
T= .01073 PHI= 187.418 PHDOT= 188.739 PSI= 312.454 PSIDOT= 192.390 PHITOT = 52.418
T= .01074 PHI= 187.529 PHDOT= 199.150 PSI= 312.564 PSIDOT= 192.390 PHITOT = 52.529
T= .01075 PHI= 187.646 PHDOT= 209.562 PSI= 312.674 PSIDOT= 192.390 PHITOT = 52.646
T= .01076 PHI= 187.769 PHDOT= 219.974 PSI= 312.784 PSIDOT= 192.390 PHITOT = 52.769
T= .01077 PHI= 187.898 PHDOT= 230.386 PSI= 312.895 PSIDOT= 192.390 PHITOT = 52.898
T= .01078 PHI= 188.033 PHDOT= 240.797 PSI= 313.005 PSIDOT= 192.390 PHITOT = 53.033
T= .01079 PHI= 188.174 PHDOT= 251.209 PSI= 313.115 PSIDOT= 192.390 PHITOT = 53.174
T= .01080 PHI= 188.321 PHDOT= 261.621 PSI= 313.225 PSIDOT= 192.390 PHITOT = 53.321
T= .01081 PHI= 188.474 PHDOT= 272.033 PSI= 313.336 PSIDOT= 192.390 PHITOT = 53.474
T= .01082 PHI= 188.632 PHDOT= 282.444 PSI= 313.446 PSIDOT= 192.390 PHITOT = 53.632
T= .01083 PHI= 188.797 PHDOT= 292.856 PSI= 313.556 PSIDOT= 192.390 PHITOT = 53.797
T= .01084 PHI= 188.968 PHDOT= 303.268 PSI= 313.666 PSIDOT= 192.390 PHITOT = 53.968
T= .01085 PHI= 189.145 PHDOT= 313.680 PSI= 313.776 PSIDOT= 192.390 PHITOT = 54.145
T= .01086 PHI= 189.327 PHDOT= 324.092 PSI= 313.887 PSIDOT= 192.390 PHITOT = 54.327
T= .01087 PHI= 189.515 PHDOT= 334.503 PSI= 313.997 PSIDOT= 192.390 PHITOT = 54.516
T= .01088 PHI= 189.711 PHDOT= 344.915 PSI= 314.107 PSIDOT= 192.390 PHITOT = 54.711
T= .01089 PHI= 189.911 PHDOT= 355.327 PSI= 314.217 PSIDOT= 192.390 PHITOT = 54.911
T= .01090 PHI= 190.118 PHDOT= 365.739 PSI= 314.328 PSIDOT= 192.390 PHITOT = 55.118
T= .01091 PHI= 190.330 PHDOT= 376.150 PSI= 314.438 PSIDOT= 192.390 PHITOT = 55.330
T= .01092 PHI= 190.549 PHDOT= 386.562 PSI= 314.548 PSIDOT= 192.390 PHITOT = 55.549
T= .01093 PHI= 190.773 PHDOT= 396.974 PSI= 314.658 PSIDOT= 192.390 PHITOT = 55.773
T= .01094 PHI= 191.004 PHDOT= 407.386 PSI= 314.769 PSIDOT= 192.390 PHITOT = 56.004
T= .01095 PHI= 191.240 PHDOT= 417.797 PSI= 314.879 PSIDOT= 192.390 PHITOT = 56.240
T= .01096 PHI= 191.483 PHDOT= 428.209 PSI= 314.989 PSIDOT= 192.390 PHITOT = 56.483
T= .01097 PHI= 191.731 PHDOT= 438.621 PSI= 315.099 PSIDOT= 192.390 PHITOT = 56.731
T= .01098 PHI= 191.985 PHDOT= 449.033 PSI= 315.209 PSIDOT= 192.390 PHITOT = 56.985
T= .01099 PHI= 192.245 PHDOT= 459.444 PSI= 315.320 PSIDOT= 192.390 PHITOT = 57.245
T= .01100 PHI= 192.512 PHDOT= 469.856 PSI= 315.430 PSIDOT= 192.390 PHITOT = 57.512
T= .01101 PHI= 192.784 PHDOT= 480.268 PSI= 315.540 PSIDOT= 192.390 PHITOT = 57.784

T= .01102 PHI= 193.062 PHIDOT= 490.680 PSI= 315.650 PSIDOT= 192.390 PHITOT = 58.062
T= .01103 PHI= 193.346 PHIDOT= 501.092 PSI= 315.761 PSIDOT= 192.390 PHITOT = 58.346
T= .01104 PHI= 193.636 PHIDOT= 511.503 PSI= 315.871 PSIDOT= 192.390 PHITOT = 58.636
VP= -17.741 VS= 41.358

IMPACT

PHI= 193.636 DPHIF= -76.532 PSI= 315.871 DPSIF= 67.186 PHITOT= 58.636
VP= -6.188 VS= -6.188

COUPLED MOTION

T= .01104	PHI= 193.636	PHIDOT= -76.532	G= -.0405	GDOT= -10.831	PSID= 315.771	PSIDOT= 67.144	PHITOT = 58.636
T= .01114	PHI= 193.243	PHIDOT= -46.502	G= -.0413	GDOT= -6.521	PSID= 316.079	PSIDOT= 60.212	PHITOT = 58.243
T= .01124	PHI= 193.105	PHIDOT= -15.478	G= -.0418	GDOT= -2.140	PSID= 316.237	PSIDOT= 13.288	PHITOT = 58.105
T= .01125	PHI= 193.096	PHIDOT= -11.562	G= -.0418	GDOT= -1.614	PSID= 316.260	PSIDOT= 9.923	PHITOT = 58.096
T= .01126	PHI= 193.089	PHIDOT= -7.669	G= -.0418	GDOT= -1.046	PSID= 316.266	PSIDOT= 6.558	PHITOT = 58.089
T= .01127	PHI= 193.086	PHIDOT= -5.683	G= -.0418	GDOT= -.793	PSID= 316.268	PSIDOT= 4.875	PHITOT = 58.086
T= .01128	PHI= 193.085	PHIDOT= -3.729	G= -.0418	GDOT= -.519	PSID= 316.270	PSIDOT= 3.193	PHITOT = 58.085
T= .01128	PHI= 193.084	PHIDOT= -2.741	G= -.0418	GDOT= -.382	PSID= 316.270	PSIDOT= 2.351	PHITOT = 58.084
T= .01128	PHI= 193.084	PHIDOT= -1.760	G= -.0418	GDOT= -.246	PSID= 316.271	PSIDOT= 1.510	PHITOT = 58.084
T= .01129	PHI= 193.084	PHIDOT= -1.270	G= -.0418	GDOT= -.177	PSID= 316.271	PSIDOT= 1.089	PHITOT = 58.084
T= .01129	PHI= 193.083	PHIDOT= -.780	G= -.0418	GDOT= -.109	PSID= 316.271	PSIDOT= .669	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.536	G= -.0418	GDOT= -.075	PSID= 316.271	PSIDOT= .458	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.293	G= -.0418	GDOT= -.040	PSID= 316.271	PSIDOT= .248	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.167	G= -.0418	GDOT= -.023	PSID= 316.271	PSIDOT= .143	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.044	G= -.0418	GDOT= -.006	PSID= 316.271	PSIDOT= .039	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .062	G= -.0418	GDOT= .009	PSID= 316.271	PSIDOT= -.053	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .123	G= -.0418	GDOT= .017	PSID= 316.271	PSIDOT= -.105	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .184	G= -.0418	GDOT= .026	PSID= 316.271	PSIDOT= -.157	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .244	G= -.0418	GDOT= .034	PSID= 316.271	PSIDOT= -.209	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .306	G= -.0418	GDOT= .042	PSID= 316.271	PSIDOT= -.261	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .355	G= -.0418	GDOT= .051	PSID= 316.271	PSIDOT= -.313	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .484	G= -.0418	GDOT= .068	PSID= 316.271	PSIDOT= -.417	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .607	G= -.0418	GDOT= .085	PSID= 316.271	PSIDOT= -.521	PHITOT = 58.083
T= .01129	PHI= 193.084	PHIDOT= .849	G= -.0418	GDOT= .118	PSID= 316.271	PSIDOT= -.729	PHITOT = 58.084
T= .01130	PHI= 193.084	PHIDOT= 1.091	G= -.0418	GDOT= .152	PSID= 316.271	PSIDOT= -.936	PHITOT = 58.084
T= .01130	PHI= 193.084	PHIDOT= 1.576	G= -.0418	GDOT= .220	PSID= 316.271	PSIDOT= -1.352	PHITOT = 58.084
T= .01130	PHI= 193.084	PHIDOT= 2.060	G= -.0418	GDOT= .287	PSID= 316.270	PSIDOT= -1.767	PHITOT = 58.084
T= .01131	PHI= 193.085	PHIDOT= 3.028	G= -.0418	GDOT= .422	PSID= 316.269	PSIDOT= -2.594	PHITOT = 58.085
T= .01131	PHI= 193.086	PHIDOT= 3.997	G= -.0418	GDOT= .558	PSID= 316.268	PSIDOT= -3.429	PHITOT = 58.086
T= .01133	PHI= 193.090	PHIDOT= 5.931	G= -.0418	GDOT= .828	PSID= 316.265	PSIDOT= -5.090	PHITOT = 58.090
T= .01134	PHI= 193.095	PHIDOT= 7.864	G= -.0418	GDOT= 1.098	PSID= 316.261	PSIDOT= -6.752	PHITOT = 58.095
T= .01136	PHI= 193.109	PHIDOT= 11.731	G= -.0418	GDOT= 1.634	PSID= 316.229	PSIDOT= -10.076	PHITOT = 58.109
T= .01139	PHI= 193.128	PHIDOT= 15.588	G= -.0417	GDOT= 2.177	PSID= 316.212	PSIDOT= -13.396	PHITOT = 58.128
T= .01141	PHI= 193.154	PHIDOT= 19.432	G= -.0417	GDOT= 2.716	PSID= 316.191	PSIDOT= -16.716	PHITOT = 58.154
T= .01144	PHI= 193.184	PHIDOT= 23.261	G= -.0416	GDOT= 3.253	PSID= 316.166	PSIDOT= -20.034	PHITOT = 58.184
T= .01149	PHI= 193.262	PHIDOT= 30.862	G= -.0414	GDOT= 4.325	PSID= 316.097	PSIDOT= -26.666	PHITOT = 58.262
T= .01154	PHI= 193.361	PHIDOT= 38.369	G= -.0411	GDOT= 5.391	PSID= 316.012	PSIDOT= -33.283	PHITOT = 58.361
T= .01159	PHI= 193.481	PHIDOT= 45.754	G= -.0409	GDOT= 6.449	PSID= 315.907	PSIDOT= -39.889	PHITOT = 58.481
T= .01164	PHI= 193.623	PHIDOT= 53.005	G= -.0405	GDOT= 7.498	PSID= 315.783	PSIDOT= -46.477	PHITOT = 58.623
T= .01174	PHI= 193.967	PHIDOT= 67.006	G= -.0397	GDOT= 9.545	PSID= 315.479	PSIDOT= -59.590	PHITOT = 58.967
T= .01184	PHI= 194.389	PHIDOT= 80.194	G= -.03A6	GDOT= 11.581	PSID= 315.100	PSIDOT= -72.594	PHITOT = 59.389
T= .01194	PHI= 194.884	PHIDOT= 92.456	G= -.0373	GDOT= 13.596	PSID= 314.648	PSIDOT= -85.467	PHITOT = 59.884
T= .01204	PHI= 195.446	PHIDOT= 103.641	G= -.0359	GDOT= 15.583	PSID= 314.121	PSIDOT= -98.170	PHITOT = 60.446
T= .01214	PHI= 196.070	PHIDOT= 113.674	G= -.0343	GDOT= 17.533	PSID= 313.523	PSIDOT=-110.674	PHITOT = 61.070
T= .01224	PHI= 196.747	PHIDOT= 122.458	G= -.0326	GDOT= 19.440	PSID= 312.854	PSIDOT=-122.943	PHITOT = 61.747
T= .01234	PHI= 197.470	PHIDOT= 129.955	G= -.0305	GDOT= 20.599	PSID= 312.115	PSIDOT=-134.940	PHITOT = 62.470
T= .01244	PHI= 198.233	PHIDOT= 136.120	G= -.0283	GDOT= 22.145	PSID= 311.308	PSIDOT=-146.630	PHITOT = 63.233
T= .01254	PHI= 199.028	PHIDOT= 140.955	G= -.0260	GDOT= 23.595	PSID= 310.435	PSIDOT=-157.975	PHITOT = 64.028
T= .01264	PHI= 199.846	PHIDOT= 144.471	G= -.0236	GDOT= 24.945	PSID= 309.498	PSIDOT=-168.940	PHITOT = 64.846
T= .01274	PHI= 200.681	PHIDOT= 146.706	G= -.0211	GDOT= 26.194	PSID= 308.500	PSIDOT=-179.490	PHITOT = 65.681
T= .01284	PHI= 201.525	PHIDOT= 147.694	G= -.0186	GDOT= 27.340	PSID= 307.442	PSIDOT=-189.595	PHITOT = 66.525
T= .01294	PHI= 202.371	PHIDOT= 147.524	G= -.0156	GDOT= 28.382	PSID= 306.328	PSIDOT=-199.226	PHITOT = 67.371
T= .01304	PHI= 203.213	PHIDOT= 146.258	G= -.0127	GDOT= 29.322	PSID= 305.160	PSIDOT=-208.358	PHITOT = 68.213
T= .01314	PHI= 204.045	PHIDOT= 143.996	G= -.0097	GDOT= 30.158	PSID= 303.942	PSIDOT=-216.971	PHITOT = 69.045
T= .01324	PHI= 204.861	PHIDOT= 140.837	G= -.0067	GDOT= 30.894	PSID= 302.675	PSIDOT=-225.049	PHITOT = 69.861

```
T=  .01334   PHI= 205.657   PHIDOT= 136.871   G=  -.0036   GDOT=  31.529   PSID= 301.364   PSIDOT=-232.381   PHITOT =  70.057
T=  .01344   PHI= 206.429   PHIDOT= 132.217   G=  -.0004   GDOT=  32.047   PSID= 300.011   PSIDOT=-239.559   PHITOT =  71.429
T=  .01354   PHI= 207.171   PHIDOT= 126.961   G=   .0029   GDOT=  32.511   PSID= 298.620   PSIDOT=-245.981   PHITOT =  72.171

FREE MOTION
T=  .01354   PHI= 127.171   PHDOT= 126.961   PSI=  47.957   PSIDOT=-245.981   PHITOT =  72.171
T=  .01355   PHI= 127.247   PHDOT= 137.372   PSI=  47.816   PSIDOT=-245.981   PHITOT =  72.247
T=  .01356   PHI= 127.329   PHDOT= 147.784   PSI=  47.675   PSIDOT=-245.981   PHITOT =  72.329
T=  .01357   PHI= 127.416   PHDOT= 158.196   PSI=  47.534   PSIDOT=-245.981   PHITOT =  72.416
T=  .01358   PHI= 127.510   PHDOT= 168.608   PSI=  47.393   PSIDOT=-245.981   PHITOT =  72.510
T=  .01359   PHI= 127.610   PHDOT= 179.019   PSI=  47.252   PSIDOT=-245.981   PHITOT =  72.610
T=  .01360   PHI= 127.715   PHDOT= 189.431   PSI=  47.111   PSIDOT=-245.981   PHITOT =  72.715
T=  .01361   PHI= 127.827   PHDOT= 199.843   PSI=  46.970   PSIDOT=-245.981   PHITOT =  72.827
T=  .01362   PHI= 127.944   PHDOT= 210.255   PSI=  46.829   PSIDOT=-245.981   PHITOT =  72.944
T=  .01363   PHI= 128.068   PHDOT= 220.667   PSI=  46.688   PSIDOT=-245.981   PHITOT =  73.068
T=  .01364   PHI= 128.197   PHDOT= 231.078   PSI=  46.547   PSIDOT=-245.981   PHITOT =  73.197
T=  .01365   PHI= 128.332   PHDOT= 241.490   PSI=  46.407   PSIDOT=-245.981   PHITOT =  73.332
T=  .01366   PHI= 128.474   PHDOT= 251.902   PSI=  46.266   PSIDOT=-245.981   PHITOT =  73.474
T=  .01367   PHI= 128.621   PHDOT= 262.314   PSI=  46.125   PSIDOT=-245.981   PHITOT =  73.621
T=  .01368   PHI= 128.774   PHDOT= 272.725   PSI=  45.984   PSIDOT=-245.981   PHITOT =  73.774
T=  .01369   PHI= 128.934   PHDOT= 283.137   PSI=  45.843   PSIDOT=-245.981   PHITOT =  73.934
T=  .01370   PHI= 129.099   PHDOT= 293.549   PSI=  45.702   PSIDOT=-245.981   PHITOT =  74.099
T=  .01371   PHI= 129.270   PHDOT= 303.961   PSI=  45.561   PSIDOT=-245.981   PHITOT =  74.270
T=  .01372   PHI= 129.447   PHDOT= 314.372   PSI=  45.420   PSIDOT=-245.981   PHITOT =  74.447
T=  .01373   PHI= 129.630   PHDOT= 324.784   PSI=  45.279   PSIDOT=-245.981   PHITOT =  74.630
T=  .01374   PHI= 129.819   PHDOT= 335.196   PSI=  45.138   PSIDOT=-245.981   PHITOT =  74.819
T=  .01375   PHI= 130.014   PHDOT= 345.608   PSI=  44.997   PSIDOT=-245.981   PHITOT =  75.014
T=  .01376   PHI= 130.215   PHDOT= 356.019   PSI=  44.856   PSIDOT=-245.981   PHITOT =  75.215
T=  .01377   PHI= 130.422   PHDOT= 366.431   PSI=  44.715   PSIDOT=-245.981   PHITOT =  75.422
T=  .01378   PHI= 130.635   PHDOT= 376.843   PSI=  44.574   PSIDOT=-245.981   PHITOT =  75.635
T=  .01379   PHI= 130.854   PHDOT= 387.255   PSI=  44.433   PSIDOT=-245.981   PHITOT =  75.854
T=  .01380   PHI= 131.079   PHDOT= 397.667   PSI=  44.292   PSIDOT=-245.981   PHITOT =  76.079
T=  .01381   PHI= 131.310   PHDOT= 408.078   PSI=  44.152   PSIDOT=-245.981   PHITOT =  76.310
T=  .01382   PHI= 131.547   PHDOT= 418.490   PSI=  44.011   PSIDOT=-245.981   PHITOT =  76.547
T=  .01383   PHI= 131.789   PHDOT= 428.902   PSI=  43.870   PSIDOT=-245.981   PHITOT =  76.789
T=  .01384   PHI= 132.038   PHDOT= 439.314   PSI=  43.729   PSIDOT=-245.981   PHITOT =  77.038
T=  .01385   PHI= 132.293   PHDOT= 449.725   PSI=  43.588   PSIDOT=-245.981   PHITOT =  77.293
T=  .01386   PHI= 132.553   PHDOT= 460.137   PSI=  43.447   PSIDOT=-245.981   PHITOT =  77.553
T=  .01387   PHI= 132.820   PHDOT= 470.549   PSI=  43.306   PSIDOT=-245.981   PHITOT =  77.820
T=  .01388   PHI= 133.093   PHDOT= 480.961   PSI=  43.165   PSIDOT=-245.981   PHITOT =  78.093
T=  .01389   PHI= 133.371   PHDOT= 491.372   PSI=  43.024   PSIDOT=-245.981   PHITOT =  78.371
T=  .01390   PHI= 133.656   PHDOT= 501.784   PSI=  42.883   PSIDOT=-245.981   PHITOT =  78.656
T=  .01391   PHI= 133.946   PHDOT= 512.196   PSI=  42.742   PSIDOT=-245.981   PHITOT =  78.946
T=  .01392   PHI= 134.243   PHDOT= 522.608   PSI=  42.601   PSIDOT=-245.981   PHITOT =  79.243
T=  .01393   PHI= 134.545   PHDOT= 533.019   PSI=  42.460   PSIDOT=-245.981   PHITOT =  79.545
T=  .01394   PHI= 134.853   PHDOT= 543.431   PSI=  42.319   PSIDOT=-245.981   PHITOT =  79.853
T=  .01395   PHI= 135.168   PHDOT= 553.843   PSI=  42.178   PSIDOT=-245.981   PHITOT =  80.168
VP= -14.378   VS=  42.251

IMPACT     Cycle No. 3

             PHI= 135.168   DPHIF=-115.001   PSI=  42.178   DPSIF=-150.511   PHITOT=  80.168
VP=  -8.773   VS=  -8.773

COUPLED MOTION
T=  .01395   PHI= 135.168   PHIDOT=-115.001   G=  -.0450   GDOT= -24.727   PSID=  42.629   PSIDOT=-149.963   PHITOT =  80.168
T=  .01405   PHI= 134.567   PHIDOT= -94.244   G=  -.0473   GDOT= -20.043   PSID=  41.861   PSIDOT=-118.939   PHITOT =  79.567
T=  .01415   PHI= 134.092   PHIDOT= -71.470   G=  -.0490   GDOT= -15.046   PSID=  41.247   PSIDOT=  -88.311   PHITOT =  79.092
T=  .01425   PHI= 133.751   PHIDOT= -47.064   G=  -.0503   GDOT=  -9.855   PSID=  40.850   PSIDOT=  -57.244   PHITOT =  78.751
T=  .01435   PHI= 133.555   PHIDOT= -21.492   G=  -.0510   GDOT=  -4.443   PSID=  40.611   PSIDOT=  -25.901   PHITOT =  78.555
T=  .01437   PHI= 133.528   PHIDOT= -14.987   G=  -.0511   GDOT=  -3.124   PSID=  40.568   PSIDOT=  -18.040   PHITOT =  78.528
T=  .01440   PHI= 133.512   PHIDOT=  -8.459   G=  -.0512   GDOT=  -1.743   PSID=  40.560   PSIDOT=  -10.174   PHITOT =  78.512
T=  .01441   PHI= 133.507   PHIDOT=  -5.180   G=  -.0512   GDOT=  -1.041   PSID=  40.554   PSIDOT=   -6.239   PHITOT =  78.507
T=  .01442   PHI= 133.504   PHIDOT=  -1.917   G=  -.0512   GDOT=   -.399   PSID=  40.551   PSIDOT=   -2.306   PHITOT =  78.504
T=  .01443   PHI= 133.504   PHIDOT=  -1.094   G=  -.0512   GDOT=   -.229   PSID=  40.551   PSIDOT=   -1.321   PHITOT =  78.504
T=  .01443   PHI= 133.504   PHIDOT=   -.280   G=  -.0512   GDOT=   -.058   PSID=  40.550   PSIDOT=    -.337   PHITOT =  78.504
```

```
T=  .05027   PHI= 134.310   PHIDOT= 544.586   PSI=  43.632   PSIDOT=-235.663   PHITOT = 279.310
T=  .05028   PHI= 134.625   PHIDOT= 554.998   PSI=  43.497   PSIDOT=-235.663   PHITOT = 279.625
T=  .05029   PHI= 134.946   PHIDOT= 565.410   PSI=  43.362   PSIDOT=-235.663   PHITOT = 279.946
T=  .05030   PHI= 135.273   PHIDOT= 575.822   PSI=  43.227   PSIDOT=-235.663   PHITOT = 280.273
T=  .05031   PHI= 135.606   PHIDOT= 586.233   PSI=  43.092   PSIDOT=-235.663   PHITOT = 280.606
VP= -13.887   VS=  45.689

IMPACT      Cycle No. 8

            PHI= 135.606   DPHIF=-184.424   PSI=  43.092   DPSIF=-134.187   PHITOT= 288.606
VP=  -8.138   VS=  -8.138

COUPLED MOTION
T=  .05031   PHI= 135.606   PHIDOT=-184.424   G=  -.0434   GDOT= -22.626   PSID=  43.201   PSIDOT=-137.765   PHITOT = 280.606
T=  .05041   PHI= 135.064   PHIDOT= -86.235   G=  -.0454   GDOT= -18.078   PSID=  42.495   PSIDOT=-108.631   PHITOT = 280.064
T=  .05051   PHI= 134.644   PHIDOT= -62.366   G=  -.0470   GDOT= -13.282   PSID=  41.957   PSIDOT= -79.973   PHITOT = 279.644
T=  .05061   PHI= 134.352   PHIDOT= -39.158   G=  -.0481   GDOT=  -8.293   PSID=  41.591   PSIDOT= -68.941   PHITOT = 279.352
T=  .05071   PHI= 134.197   PHIDOT= -15.049   G=  -.0487   GDOT=  -3.178   PSID=  41.397   PSIDOT= -18.479   PHITOT = 279.197
T=  .05073   PHI= 134.179   PHIDOT=  -8.944   G=  -.0487   GDOT=  -1.888   PSID=  41.376   PSIDOT= -11.994   PHITOT = 279.179
T=  .05076   PHI= 134.171   PHIDOT=  -2.828   G=  -.0487   GDOT=   -.597   PSID=  41.365   PSIDOT=  -3.506   PHITOT = 279.171
T=  .05076   PHI= 134.171   PHIDOT=  -2.061   G=  -.0487   GDOT=   -.435   PSID=  41.365   PSIDOT=  -2.558   PHITOT = 279.171
T=  .05077   PHI= 134.170   PHIDOT=  -1.293   G=  -.0487   GDOT=   -.274   PSID=  41.364   PSIDOT=  -1.609   PHITOT = 279.170
T=  .05077   PHI= 134.170   PHIDOT=   -.915   G=  -.0487   GDOT=   -.193   PSID=  41.364   PSIDOT=  -1.135   PHITOT = 279.170
T=  .05077   PHI= 134.170   PHIDOT=   -.533   G=  -.0487   GDOT=   -.112   PSID=  41.364   PSIDOT=   -.660   PHITOT = 279.170
T=  .05077   PHI= 134.170   PHIDOT=   -.150   G=  -.0487   GDOT=   -.032   PSID=  41.364   PSIDOT=   -.186   PHITOT = 279.170
T=  .05077   PHI= 134.170   PHIDOT=    .150   G=  -.0487   GDOT=    .032   PSID=  41.364   PSIDOT=    .186   PHITOT = 279.170
T=  .05077   PHI= 134.170   PHIDOT=    .221   G=  -.0487   GDOT=    .047   PSID=  41.364   PSIDOT=    .274   PHITOT = 279.170
T=  .05078   PHI= 134.170   PHIDOT=    .293   G=  -.0487   GDOT=    .062   PSID=  41.364   PSIDOT=    .363   PHITOT = 279.170
T=  .05078   PHI= 134.170   PHIDOT=    .364   G=  -.0487   GDOT=    .077   PSID=  41.364   PSIDOT=    .451   PHITOT = 279.170
T=  .05078   PHI= 134.170   PHIDOT=    .436   G=  -.0487   GDOT=    .092   PSID=  41.364   PSIDOT=    .539   PHITOT = 279.170
T=  .05078   PHI= 134.170   PHIDOT=    .577   G=  -.0487   GDOT=    .122   PSID=  41.364   PSIDOT=    .715   PHITOT = 279.170
T=  .05078   PHI= 134.170   PHIDOT=    .719   G=  -.0487   GDOT=    .152   PSID=  41.364   PSIDOT=    .892   PHITOT = 279.170
T=  .05079   PHI= 134.171   PHIDOT=   1.004   G=  -.0487   GDOT=    .212   PSID=  41.365   PSIDOT=   1.245   PHITOT = 279.171
T=  .05080   PHI= 134.171   PHIDOT=   1.288   G=  -.0487   GDOT=    .272   PSID=  41.365   PSIDOT=   1.598   PHITOT = 279.171
T=  .05080   PHI= 134.172   PHIDOT=   1.573   G=  -.0487   GDOT=    .332   PSID=  41.366   PSIDOT=   1.950   PHITOT = 279.172
T=  .05081   PHI= 134.172   PHIDOT=   1.857   G=  -.0487   GDOT=    .392   PSID=  41.367   PSIDOT=   2.303   PHITOT = 279.172
T=  .05082   PHI= 134.174   PHIDOT=   2.424   G=  -.0487   GDOT=    .512   PSID=  41.369   PSIDOT=   3.009   PHITOT = 279.174
T=  .05083   PHI= 134.176   PHIDOT=   2.995   G=  -.0487   GDOT=    .632   PSID=  41.371   PSIDOT=   3.715   PHITOT = 279.176
T=  .05085   PHI= 134.178   PHIDOT=   3.566   G=  -.0487   GDOT=    .752   PSID=  41.374   PSIDOT=   4.420   PHITOT = 279.178
T=  .05086   PHI= 134.181   PHIDOT=   4.137   G=  -.0487   GDOT=    .872   PSID=  41.377   PSIDOT=   5.126   PHITOT = 279.181
T=  .05088   PHI= 134.188   PHIDOT=   5.280   G=  -.0487   GDOT=   1.112   PSID=  41.386   PSIDOT=   6.537   PHITOT = 279.188
T=  .05091   PHI= 134.196   PHIDOT=   6.403   G=  -.0487   GDOT=   1.352   PSID=  41.396   PSIDOT=   7.948   PHITOT = 279.196
T=  .05096   PHI= 134.217   PHIDOT=   8.667   G=  -.0486   GDOT=   1.831   PSID=  41.423   PSIDOT=  10.769   PHITOT = 279.217
T=  .05101   PHI= 134.246   PHIDOT=  10.929   G=  -.0485   GDOT=   2.309   PSID=  41.458   PSIDOT=  13.589   PHITOT = 279.246
T=  .05106   PHI= 134.280   PHIDOT=  13.160   G=  -.0483   GDOT=   2.785   PSID=  41.501   PSIDOT=  16.408   PHITOT = 279.280
T=  .05111   PHI= 134.321   PHIDOT=  15.401   G=  -.0482   GDOT=   3.260   PSID=  41.552   PSIDOT=  19.225   PHITOT = 279.321
T=  .05121   PHI= 134.422   PHIDOT=  19.819   G=  -.0478   GDOT=   4.204   PSID=  41.678   PSIDOT=  24.853   PHITOT = 279.422
T=  .05131   PHI= 134.549   PHIDOT=  24.156   G=  -.0474   GDOT=   5.137   PSID=  41.834   PSIDOT=  30.471   PHITOT = 279.548
T=  .05141   PHI= 134.699   PHIDOT=  28.420   G=  -.0468   GDOT=   6.059   PSID=  42.027   PSIDOT=  36.077   PHITOT = 279.699
T=  .05151   PHI= 134.873   PHIDOT=  32.577   G=  -.0461   GDOT=   6.967   PSID=  42.250   PSIDOT=  41.669   PHITOT = 279.873
T=  .05161   PHI= 135.072   PHIDOT=  36.623   G=  -.0454   GDOT=   7.861   PSID=  42.505   PSIDOT=  47.245   PHITOT = 280.072
T=  .05171   PHI= 135.293   PHIDOT=  40.551   G=  -.0446   GDOT=   8.738   PSID=  42.791   PSIDOT=  52.805   PHITOT = 280.293
T=  .05181   PHI= 135.536   PHIDOT=  44.351   G=  -.0437   GDOT=   9.599   PSID=  43.110   PSIDOT=  58.347   PHITOT = 280.536
T=  .05191   PHI= 135.801   PHIDOT=  48.024   G=  -.0427   GDOT=  10.441   PSID=  43.460   PSIDOT=  63.870   PHITOT = 280.801
T=  .05201   PHI= 136.086   PHIDOT=  51.564   G=  -.0416   GDOT=  11.265   PSID=  43.841   PSIDOT=  69.373   PHITOT = 281.086
T=  .05211   PHI= 136.392   PHIDOT=  54.973   G=  -.0404   GDOT=  12.069   PSID=  44.255   PSIDOT=  74.856   PHITOT = 281.392
T=  .05221   PHI= 136.716   PHIDOT=  58.244   G=  -.0392   GDOT=  12.855   PSID=  44.699   PSIDOT=  80.318   PHITOT = 281.716
T=  .05231   PHI= 137.059   PHIDOT=  61.380   G=  -.0378   GDOT=  13.621   PSID=  45.175   PSIDOT=  85.761   PHITOT = 282.059
T=  .05241   PHI= 137.419   PHIDOT=  64.401   G=  -.0364   GDOT=  14.368   PSID=  45.682   PSIDOT=  91.123   PHITOT = 282.419
T=  .05251   PHI= 137.796   PHIDOT=  67.293   G=  -.0350   GDOT=  15.096   PSID=  46.220   PSIDOT=  96.586   PHITOT = 282.796
T=  .05261   PHI= 138.190   PHIDOT=  70.065   G=  -.0334   GDOT=  15.806   PSID=  46.789   PSIDOT= 101.970   PHITOT = 283.190
T=  .05271   PHI= 138.599   PHIDOT=  72.723   G=  -.0318   GDOT=  16.497   PSID=  47.388   PSIDOT= 107.336   PHITOT = 283.599
T=  .05281   PHI= 139.023   PHIDOT=  75.279   G=  -.0301   GDOT=  17.171   PSID=  48.019   PSIDOT= 112.686   PHITOT = 284.023
T=  .05291   PHI= 139.462   PHIDOT=  77.729   G=  -.0284   GDOT=  17.827   PSID=  48.680   PSIDOT= 118.020   PHITOT = 284.462
T=  .05301   PHI= 139.914   PHIDOT=  80.078   G=  -.0265   GDOT=  18.467   PSID=  49.371   PSIDOT= 123.340   PHITOT = 284.914
T=  .05311   PHI= 140.379   PHIDOT=  82.364   G=  -.0247   GDOT=  19.090   PSID=  50.093   PSIDOT= 128.647   PHITOT = 285.379
```

```
T=  .05321   PHI= 140.857   PHIDOT=  94.531   G=  -.0227   GDOT=  19.897   PSID=  50.945   PSIDOT= 131.946   PHITOT = 293.857
T=  .05331   PHI= 141.348   PHIDOT=  86.666   G=  -.0207   GDOT=  20.289   PSID=  51.628   PSIDOT= 139.231   PHITOT = 294.348
T=  .05341   PHI= 141.850   PHIDOT=  88.691   G=  -.0187   GDOT=  20.866   PSID=  52.441   PSIDOT= 146.511   PHITOT = 294.850
T=  .05351   PHI= 142.364   PHIDOT=  90.675   G=  -.0166   GDOT=  21.428   PSID=  53.284   PSIDOT= 149.786   PHITOT = 295.364
T=  .05361   PHI= 142.889   PHIDOT=  92.604   G=  -.0144   GDOT=  21.977   PSID=  54.157   PSIDOT= 155.856   PHITOT = 295.889
T=  .05371   PHI= 143.425   PHIDOT=  94.491   G=  -.0122   GDOT=  22.511   PSID=  55.061   PSIDOT= 160.325   PHITOT = 296.425
T=  .05381   PHI= 143.971   PHIDOT=  96.318   G=  -.0099   GDOT=  23.032   PSID=  55.994   PSIDOT= 165.594   PHITOT = 296.971
T=  .05391   PHI= 144.528   PHIDOT=  98.114   G=  -.0076   GDOT=  23.539   PSID=  56.958   PSIDOT= 170.866   PHITOT = 297.528
T=  .05401   PHI= 145.096   PHIDOT=  99.874   G=  -.0052   GDOT=  24.034   PSID=  57.952   PSIDOT= 174.138   PHITOT = 298.096
T=  .05411   PHI= 145.673   PHIDOT= 101.608   G=  -.0027   GDOT=  24.515   PSID=  58.977   PSIDOT= 181.417   PHITOT = 298.673
T=  .05421   PHI= 146.260   PHIDOT= 103.316   G=  -.0003   GDOT=  24.983   PSID=  60.031   PSIDOT= 184.703   PHITOT = 299.260
T=  .05431   PHI= 146.857   PHIDOT= 104.998   G=   .0022   GDOT=  25.437   PSID=  61.116   PSIDOT= 191.998   PHITOT = 299.857

FREE MOTION
T=  .05431   PHI= 146.857   PHIDOT= 104.998   PSI= 311.779   PSIDOT= 191.998   PHITOT = 299.857
T=  .05432   PHI= 146.920   PHIDOT= 115.410   PSI= 311.889   PSIDOT= 191.998   PHITOT = 299.920
T=  .05433   PHI= 146.989   PHIDOT= 125.821   PSI= 311.998   PSIDOT= 191.998   PHITOT = 299.989
T=  .05434   PHI= 147.064   PHIDOT= 136.233   PSI= 312.109   PSIDOT= 191.998   PHITOT = 300.064
T=  .05435   PHI= 147.145   PHIDOT= 146.645   PSI= 312.219   PSIDOT= 191.998   PHITOT = 300.145
T=  .05436   PHI= 147.232   PHIDOT= 157.057   PSI= 312.329   PSIDOT= 191.998   PHITOT = 300.232
T=  .05437   PHI= 147.325   PHIDOT= 167.469   PSI= 312.439   PSIDOT= 191.998   PHITOT = 300.325
T=  .05438   PHI= 147.424   PHIDOT= 177.880   PSI= 312.549   PSIDOT= 191.998   PHITOT = 300.424
T=  .05439   PHI= 147.529   PHIDOT= 188.292   PSI= 312.659   PSIDOT= 191.998   PHITOT = 300.529
T=  .05440   PHI= 147.640   PHIDOT= 198.704   PSI= 312.769   PSIDOT= 191.998   PHITOT = 300.640
T=  .05441   PHI= 147.757   PHIDOT= 209.116   PSI= 312.879   PSIDOT= 191.998   PHITOT = 300.757
T=  .05442   PHI= 147.879   PHIDOT= 219.527   PSI= 312.989   PSIDOT= 191.998   PHITOT = 300.879
T=  .05443   PHI= 148.008   PHIDOT= 229.939   PSI= 313.099   PSIDOT= 191.998   PHITOT = 301.008
T=  .05444   PHI= 148.143   PHIDOT= 240.351   PSI= 313.209   PSIDOT= 191.998   PHITOT = 301.143
T=  .05445   PHI= 148.284   PHIDOT= 250.763   PSI= 313.319   PSIDOT= 191.998   PHITOT = 301.284
T=  .05446   PHI= 148.430   PHIDOT= 261.174   PSI= 313.429   PSIDOT= 191.998   PHITOT = 301.430
T=  .05447   PHI= 148.583   PHIDOT= 271.586   PSI= 313.539   PSIDOT= 191.998   PHITOT = 301.583
T=  .05448   PHI= 148.741   PHIDOT= 281.998   PSI= 313.649   PSIDOT= 191.998   PHITOT = 301.741
T=  .05449   PHI= 148.906   PHIDOT= 292.410   PSI= 313.759   PSIDOT= 191.998   PHITOT = 301.906
T=  .05450   PHI= 149.077   PHIDOT= 302.821   PSI= 313.869   PSIDOT= 191.998   PHITOT = 302.077
T=  .05451   PHI= 149.253   PHIDOT= 313.233   PSI= 313.979   PSIDOT= 191.998   PHITOT = 302.253
T=  .05452   PHI= 149.435   PHIDOT= 323.645   PSI= 314.089   PSIDOT= 191.998   PHITOT = 302.435
T=  .05453   PHI= 149.624   PHIDOT= 334.057   PSI= 314.199   PSIDOT= 191.998   PHITOT = 302.624
T=  .05454   PHI= 149.818   PHIDOT= 344.469   PSI= 314.309   PSIDOT= 191.998   PHITOT = 302.818
T=  .05455   PHI= 150.019   PHIDOT= 354.880   PSI= 314.419   PSIDOT= 191.998   PHITOT = 303.019
T=  .05456   PHI= 150.225   PHIDOT= 365.292   PSI= 314.529   PSIDOT= 191.998   PHITOT = 303.225
T=  .05457   PHI= 150.437   PHIDOT= 375.704   PSI= 314.639   PSIDOT= 191.998   PHITOT = 303.437
T=  .05458   PHI= 150.655   PHIDOT= 386.116   PSI= 314.749   PSIDOT= 191.998   PHITOT = 303.655
T=  .05459   PHI= 150.880   PHIDOT= 396.527   PSI= 314.859   PSIDOT= 191.998   PHITOT = 303.880
T=  .05460   PHI= 151.110   PHIDOT= 406.939   PSI= 314.969   PSIDOT= 191.998   PHITOT = 304.110
T=  .05461   PHI= 151.346   PHIDOT= 417.351   PSI= 315.079   PSIDOT= 191.998   PHITOT = 304.346
T=  .05462   PHI= 151.588   PHIDOT= 427.763   PSI= 315.189   PSIDOT= 191.998   PHITOT = 304.588
T=  .05463   PHI= 151.836   PHIDOT= 438.174   PSI= 315.299   PSIDOT= 191.998   PHITOT = 304.836
T=  .05464   PHI= 152.090   PHIDOT= 448.586   PSI= 315.409   PSIDOT= 191.998   PHITOT = 305.090
T=  .05465   PHI= 152.350   PHIDOT= 458.998   PSI= 315.519   PSIDOT= 191.998   PHITOT = 305.350
T=  .05466   PHI= 152.616   PHIDOT= 469.410   PSI= 315.629   PSIDOT= 191.998   PHITOT = 305.616
T=  .05467   PHI= 152.888   PHIDOT= 479.821   PSI= 315.739   PSIDOT= 191.998   PHITOT = 305.888
T=  .05468   PHI= 153.166   PHIDOT= 490.233   PSI= 315.849   PSIDOT= 191.998   PHITOT = 306.166
T=  .05469   PHI= 153.450   PHIDOT= 500.645   PSI= 315.959   PSIDOT= 191.998   PHITOT = 306.450
VP= -17.732   VS=  40.250

IMPACT

             PHI= 153.450   DPHIF= -77.927   PSI= 315.959   DPSIF=  67.838   PHITOT= 306.450
VP=  -6.245   VS=  -6.265

COUPLED MOTION
T=  .05469   PHI= 153.450   PHIDOT= -77.927   G=  -.0409   GDOT= -10.974   PSID= 315.934   PSIDOT=  67.447   PHITOT = 306.450
T=  .05479   PHI= 153.090   PHIDOT= -47.541   G=  -.0418   GDOT=  -6.633   PSID= 316.265   PSIDOT=  40.790   PHITOT = 306.090
T=  .05489   PHI= 152.907   PHIDOT= -16.134   G=  -.0423   GDOT=  -2.241   PSID= 316.407   PSIDOT=  13.743   PHITOT = 305.907
T=  .05491   PHI= 152.899   PHIDOT=  -8.204   G=  -.0423   GDOT=  -1.139   PSID= 316.417   PSIDOT=   4.982   PHITOT = 305.899
T=  .05494   PHI= 152.884   PHIDOT=   -.261   G=  -.0423   GDOT=   -.036   PSID= 316.422   PSIDOT=    .222   PHITOT = 305.884
```

T= .05494 PHI= 192.884 PHIDOT= -.137 G= -.0423 GDOT= -.019 PSID= 316.427 PSIDOT= .016 PHITOT = 297.889
T= .05494 PHI= 192.884 PHIDOT= -.011 G= -.0423 GDOT= -.002 PSID= 316.427 PSIDOT= .011 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .059 G= -.0423 GDOT= .008 PSID= 316.427 PSIDOT= -.050 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .121 G= -.0423 GDOT= .017 PSID= 316.427 PSIDOT= -.103 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .183 G= -.0423 GDOT= .025 PSID= 316.427 PSIDOT= -.155 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .244 G= -.0423 GDOT= .034 PSID= 316.427 PSIDOT= -.207 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .305 G= -.0423 GDOT= .042 PSID= 316.427 PSIDOT= -.256 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .366 G= -.0423 GDOT= .051 PSID= 316.422 PSIDOT= -.312 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .480 G= -.0423 GDOT= .068 PSID= 316.422 PSIDOT= -.416 PHITOT = 297.884
T= .05494 PHI= 192.884 PHIDOT= .617 G= -.0423 GDOT= .085 PSID= 316.422 PSIDOT= -.521 PHITOT = 297.884
T= .05495 PHI= 192.884 PHIDOT= .735 G= -.0423 GDOT= .102 PSID= 316.422 PSIDOT= -.625 PHITOT = 297.884
T= .05495 PHI= 192.884 PHIDOT= .857 G= -.0423 GDOT= .119 PSID= 316.422 PSIDOT= -.730 PHITOT = 297.884
T= .05495 PHI= 192.884 PHIDOT= 1.101 G= -.0423 GDOT= .153 PSID= 316.421 PSIDOT= -.939 PHITOT = 297.884
T= .05495 PHI= 192.884 PHIDOT= 1.343 G= -.0423 GDOT= .187 PSID= 316.421 PSIDOT= -1.148 PHITOT = 297.884
T= .05495 PHI= 192.884 PHIDOT= 1.596 G= -.0423 GDOT= .221 PSID= 316.421 PSIDOT= -1.357 PHITOT = 297.884
T= .05495 PHI= 192.884 PHIDOT= 1.840 G= -.0423 GDOT= .255 PSID= 316.421 PSIDOT= -1.566 PHITOT = 297.884
T= .05496 PHI= 192.885 PHIDOT= 2.331 G= -.0423 GDOT= .324 PSID= 316.421 PSIDOT= -1.983 PHITOT = 297.885
T= .05496 PHI= 192.885 PHIDOT= 2.822 G= -.0423 GDOT= .392 PSID= 316.420 PSIDOT= -2.401 PHITOT = 297.885
T= .05496 PHI= 192.886 PHIDOT= 3.313 G= -.0423 GDOT= .460 PSID= 316.420 PSIDOT= -2.819 PHITOT = 297.886
T= .05496 PHI= 192.886 PHIDOT= 3.804 G= -.0423 GDOT= .528 PSID= 316.419 PSIDOT= -3.237 PHITOT = 297.886
T= .05497 PHI= 192.888 PHIDOT= 4.784 G= -.0423 GDOT= .664 PSID= 316.418 PSIDOT= -4.073 PHITOT = 297.888
T= .05498 PHI= 192.890 PHIDOT= 5.764 G= -.0423 GDOT= .801 PSID= 316.417 PSIDOT= -4.909 PHITOT = 297.890
T= .05498 PHI= 192.892 PHIDOT= 6.749 G= -.0423 GDOT= .937 PSID= 316.415 PSIDOT= -5.745 PHITOT = 297.892
T= .05499 PHI= 192.894 PHIDOT= 7.730 G= -.0423 GDOT= 1.073 PSID= 316.412 PSIDOT= -6.580 PHITOT = 297.894
T= .05500 PHI= 192.901 PHIDOT= 9.691 G= -.0423 GDOT= 1.346 PSID= 316.407 PSIDOT= -8.252 PHITOT = 297.901
T= .05501 PHI= 192.908 PHIDOT= 11.650 G= -.0423 GDOT= 1.618 PSID= 316.401 PSIDOT= -9.923 PHITOT = 297.908
T= .05503 PHI= 192.917 PHIDOT= 13.607 G= -.0422 GDOT= 1.890 PSID= 316.393 PSIDOT= -11.594 PHITOT = 297.917
T= .05504 PHI= 192.928 PHIDOT= 15.561 G= -.0422 GDOT= 2.162 PSID= 316.384 PSIDOT= -13.264 PHITOT = 297.928
T= .05506 PHI= 192.953 PHIDOT= 19.460 G= -.0421 GDOT= 2.706 PSID= 316.363 PSIDOT= -16.605 PHITOT = 297.953
T= .05509 PHI= 192.984 PHIDOT= 23.344 G= -.0421 GDOT= 3.248 PSID= 316.336 PSIDOT= -19.943 PHITOT = 297.984
T= .05514 PHI= 193.061 PHIDOT= 31.054 G= -.0419 GDOT= 4.330 PSID= 316.270 PSIDOT= -26.614 PHITOT = 298.061
T= .05519 PHI= 193.161 PHIDOT= 38.660 G= -.0416 GDOT= 5.405 PSID= 316.184 PSIDOT= -33.274 PHITOT = 298.161
T= .05524 PHI= 193.283 PHIDOT= 46.164 G= -.0413 GDOT= 6.473 PSID= 316.079 PSIDOT= -39.920 PHITOT = 298.283
T= .05529 PHI= 193.426 PHIDOT= 53.518 G= -.0410 GDOT= 7.532 PSID= 315.955 PSIDOT= -46.549 PHITOT = 298.426
T= .05539 PHI= 193.773 PHIDOT= 67.716 G= -.0401 GDOT= 9.618 PSID= 315.651 PSIDOT= -59.745 PHITOT = 298.773
T= .05549 PHI= 194.200 PHIDOT= 81.101 G= -.0391 GDOT= 11.651 PSID= 315.271 PSIDOT= -72.836 PHITOT = 299.200
T= .05559 PHI= 194.701 PHIDOT= 93.530 G= -.0378 GDOT= 13.624 PSID= 314.814 PSIDOT= -85.791 PHITOT = 299.701
T= .05569 PHI= 195.270 PHIDOT= 104.878 G= -.0363 GDOT= 15.527 PSID= 314.288 PSIDOT= -98.580 PHITOT = 300.270
T= .05579 PHI= 195.900 PHIDOT= 115.043 G= -.0347 GDOT= 17.352 PSID= 313.687 PSIDOT=-111.170 PHITOT = 300.900
T= .05589 PHI= 196.586 PHIDOT= 123.948 G= -.0329 GDOT= 19.093 PSID= 313.015 PSIDOT=-123.525 PHITOT = 301.586
T= .05599 PHI= 197.318 PHIDOT= 131.534 G= -.0309 GDOT= 20.745 PSID= 312.272 PSIDOT=-135.609 PHITOT = 302.318
T= .05609 PHI= 198.090 PHIDOT= 137.777 G= -.0287 GDOT= 22.303 PSID= 311.461 PSIDOT=-147.384 PHITOT = 303.090
T= .05619 PHI= 198.895 PHIDOT= 142.669 G= -.0264 GDOT= 23.764 PSID= 310.584 PSIDOT=-158.812 PHITOT = 303.895
T= .05629 PHI= 199.723 PHIDOT= 146.204 G= -.0240 GDOT= 25.124 PSID= 309.642 PSIDOT=-169.859 PHITOT = 304.723
T= .05639 PHI= 200.567 PHIDOT= 148.443 G= -.0214 GDOT= 26.381 PSID= 308.638 PSIDOT=-180.488 PHITOT = 305.567
T= .05649 PHI= 201.421 PHIDOT= 149.424 G= -.0187 GDOT= 27.535 PSID= 307.575 PSIDOT=-190.668 PHITOT = 306.421
T= .05659 PHI= 202.277 PHIDOT= 149.229 G= -.0159 GDOT= 28.584 PSID= 306.454 PSIDOT=-200.370 PHITOT = 307.277
T= .05669 PHI= 203.129 PHIDOT= 147.914 G= -.0130 GDOT= 29.529 PSID= 305.280 PSIDOT=-209.570 PHITOT = 308.129
T= .05679 PHI= 203.970 PHIDOT= 145.593 G= -.0100 GDOT= 30.370 PSID= 304.054 PSIDOT=-218.245 PHITOT = 308.970
T= .05689 PHI= 204.796 PHIDOT= 142.359 G= -.0069 GDOT= 31.108 PSID= 302.780 PSIDOT=-226.380 PHITOT = 309.796
T= .05699 PHI= 205.600 PHIDOT= 138.315 G= -.0038 GDOT= 31.746 PSID= 301.461 PSIDOT=-233.964 PHITOT = 310.600
T= .05709 PHI= 206.379 PHIDOT= 133.564 G= -.0006 GDOT= 32.285 PSID= 300.100 PSIDOT=-240.989 PHITOT = 311.379
T= .05719 PHI= 207.130 PHIDOT= 128.220 G= .0027 GDOT= 32.729 PSID= 298.700 PSIDOT=-247.452 PHITOT = 312.130

FREE MOTION

T= .05719 PHI= 127.1 PHDOT= 128.220 PSI= 48.037 PSIDOT=-247.452 PHITOT = 312.130
T= .05720 PHI= 127.206 PHDOT= 138.631 PSI= 47.895 PSIDOT=-247.452 PHITOT = 312.206
T= .05721 PHI= 127.249 PHDOT= 149.043 PSI= 47.754 PSIDOT=-247.452 PHITOT = 312.249
T= .05722 PHI= 127.377 PHDOT= 159.455 PSI= 47.612 PSIDOT=-247.452 PHITOT = 312.377
T= .05723 PHI= 127.471 PHDOT= 169.867 PSI= 47.470 PSIDOT=-247.452 PHITOT = 312.471
T= .05724 PHI= 127.572 PHDOT= 180.278 PSI= 47.328 PSIDOT=-247.452 PHITOT = 312.572
T= .05725 PHI= 127.678 PHDOT= 190.690 PSI= 47.187 PSIDOT=-247.452 PHITOT = 312.678
T= .05726 PHI= 127.790 PHDOT= 201.102 PSI= 47.045 PSIDOT=-247.452 PHITOT = 312.790
T= .05727 PHI= 127.908 PHDOT= 211.514 PSI= 46.903 PSIDOT=-247.452 PHITOT = 312.908
T= .05728 PHI= 128.032 PHDOT= 221.925 PSI= 46.761 PSIDOT=-247.452 PHITOT = 313.032
T= .05729 PHI= 128.163 PHDOT= 232.337 PSI= 46.619 PSIDOT=-247.452 PHITOT = 313.163

```
T=  .05730   PHI= 128.299   PHDOT= 242.749   PSI=  46.478   PSIDOT=-247.452   PHITOT = 313.299
T=  .05731   PHI= 128.441   PHDOT= 253.161   PSI=  46.336   PSIDOT=-247.452   PHITOT = 313.441
T=  .05732   PHI= 128.589   PHDOT= 263.573   PSI=  46.194   PSIDOT=-247.452   PHITOT = 313.589
T=  .05733   PHI= 128.743   PHDOT= 273.984   PSI=  46.052   PSIDOT=-247.452   PHITOT = 313.743
T=  .05734   PHI= 128.903   PHDOT= 284.396   PSI=  45.911   PSIDOT=-247.452   PHITOT = 313.903
T=  .05735   PHI= 129.069   PHDOT= 294.808   PSI=  45.769   PSIDOT=-247.452   PHITOT = 314.069
T=  .05736   PHI= 129.241   PHDOT= 305.220   PSI=  45.627   PSIDOT=-247.452   PHITOT = 314.241
T=  .05737   PHI= 129.418   PHDOT= 315.631   PSI=  45.485   PSIDOT=-247.452   PHITOT = 314.418
T=  .05738   PHI= 129.602   PHDOT= 326.043   PSI=  45.343   PSIDOT=-247.452   PHITOT = 314.602
T=  .05739   PHI= 129.792   PHDOT= 336.455   PSI=  45.202   PSIDOT=-247.452   PHITOT = 314.792
T=  .05740   PHI= 129.988   PHDOT= 346.867   PSI=  45.060   PSIDOT=-247.452   PHITOT = 314.988
T=  .05741   PHI= 130.190   PHDOT= 357.278   PSI=  44.918   PSIDOT=-247.452   PHITOT = 315.190
T=  .05742   PHI= 130.397   PHDOT= 367.690   PSI=  44.776   PSIDOT=-247.452   PHITOT = 315.397
T=  .05743   PHI= 130.611   PHDOT= 378.102   PSI=  44.635   PSIDOT=-247.452   PHITOT = 315.611
T=  .05744   PHI= 130.831   PHDOT= 388.514   PSI=  44.493   PSIDOT=-247.452   PHITOT = 315.831
T=  .05745   PHI= 131.056   PHDOT= 398.925   PSI=  44.351   PSIDOT=-247.452   PHITOT = 316.056
T=  .05746   PHI= 131.288   PHDOT= 409.337   PSI=  44.209   PSIDOT=-247.452   PHITOT = 316.288
T=  .05747   PHI= 131.525   PHDOT= 419.749   PSI=  44.067   PSIDOT=-247.452   PHITOT = 316.525
T=  .05748   PHI= 131.769   PHDOT= 430.161   PSI=  43.926   PSIDOT=-247.452   PHITOT = 316.769
T=  .05749   PHI= 132.018   PHDOT= 440.573   PSI=  43.784   PSIDOT=-247.452   PHITOT = 317.018
T=  .05750   PHI= 132.273   PHDOT= 450.984   PSI=  43.642   PSIDOT=-247.452   PHITOT = 317.273
T=  .05751   PHI= 132.535   PHDOT= 461.396   PSI=  43.500   PSIDOT=-247.452   PHITOT = 317.535
T=  .05752   PHI= 132.802   PHDOT= 471.808   PSI=  43.359   PSIDOT=-247.452   PHITOT = 317.802
T=  .05753   PHI= 133.076   PHDOT= 482.220   PSI=  43.217   PSIDOT=-247.452   PHITOT = 318.076
T=  .05754   PHI= 133.355   PHDOT= 492.631   PSI=  43.075   PSIDOT=-247.452   PHITOT = 318.355
T=  .05755   PHI= 133.640   PHDOT= 503.043   PSI=  42.933   PSIDOT=-247.452   PHITOT = 318.640
T=  .05756   PHI= 133.931   PHDOT= 513.455   PSI=  42.791   PSIDOT=-247.452   PHITOT = 318.931
T=  .05757   PHI= 134.228   PHDOT= 523.867   PSI=  42.650   PSIDOT=-247.452   PHITOT = 319.228
T=  .05758   PHI= 134.532   PHDOT= 534.278   PSI=  42.508   PSIDOT=-247.452   PHITOT = 319.532
T=  .05759   PHI= 134.841   PHDOT= 544.690   PSI=  42.366   PSIDOT=-247.452   PHITOT = 319.841
T=  .05760   PHI= 135.156   PHDOT= 555.102   PSI=  42.224   PSIDOT=-247.452   PHITOT = 320.156
VP= -14.443   VS=  42.322

IMPACT

             PHI= 135.156   DPHIF=-115.965   PSI=  42.224   DPSIF=-151.480   PHITOT= 320.156
VP=  -8.841   VS=  -8.841
```

DISTRIBUTION LIST

Commander
US Army ARRADCOM
ATTN: DRDAR-LCF, F. Saxe
DRDAR-LCF, G. Demitrack
DRDAR-LCF, L. Horowitz
DRDAR-LCF, A. Nash
DRDAR-LCF, R. Brennan
DRDAR-LCF, Y. Carignan
DRDAR-LCF, B. Frey
DRDAR-LCS, M. Hauptman
DRDAR-LCF, S. Honickman
DRDAR-LCF, S. Israels
DRDAR-LCF, O. Janow
DRDAR-LCF, F. McCann
DRDAR-LCF, R. Nitzsche
DRDAR-LCF, L. Post
DRDAR-LCF, H. Rand
DRDAR-LCF, B. Schulman
DRDAR-LCF, D. Shaw
DRDAR-LCF, D. Taravella
DRDAR-LCF, F. Tepper (20)
DRDAR-LCF, A. Tese
DRDAR-LCF, L. Wisse
DRDAR-TSS (5)
Dover, NJ 07801

Commander
Harry Diamond Laboratories
ATTN: Library
DRXDO-DAB, D. Overman
Washington, DC 20436

Defense Documentation Center (2)
Cameron Station
Alexandria, VA 22314

City College of New York
Mechanical Engineering Dept.
ATTN: Prof. G. Lowen (20)
137 St. and Convent Avenue
New York, NY 10031

Commander
US Army Armament Materiel and
Readiness Command
ATTN: DRSAR-LEP-L
Rock Island, IL 61299

Director
US Army TRADOC Systems
Analysis Activity
ATTN: ATAA-SL (Tech Lib)
White Sands Missile Range, NM 88002

Weapon System Concept Team/CSL
ATTN: DRDAR-ACW
Aberdeen Proving Ground, MD 21010

Technical Library
ATTN: DRDAR-CLJ-L
Aberdeen Proving Ground, MD 21005

Technical Library
ATTN: DRDAR-TSB-S
Aberdeen Proving Ground, MD 21010

Technical Library
ATTN: DRDAR-LCB-TL
Benet Weapons Laboratory
Watervliet, NY 12189